Electrochemical and Metallurgical Industry

VOL. V. NEW YORK, JULY, 1907. No. 7.

Electrochemical and Metallurgical Industry

With which is Incorporated Iron and Steel Magazine

Published on the first of each month by the
ELECTROCHEMICAL PUBLISHING COMPANY,
[Incorporated.]
114-118 LIBERTY STREET, NEW YORK.

J. W. RICHARDS, PH. D.....*President*
E. F. ROEBER, PH. D.....*Editor and Secretary*
C. E. WHITTLESEY.....*Treasurer*

Subscription Price: $2 per year, postpaid to any part of the world. Single copies 25 cents.

Copyrighted, 1907, by the Electrochemical Publishing Co.

Entered as Second-Class Matter, June, 1906, at the Post-Office at New York, N. Y., under the Act of Congress, March 3, 1879.

NEW YORK, JULY, 1907.

CONTENTS.

EDITORIAL 253
Forty Years of Iron-Furnace Growth..... 253
Developments in the Rail Trade..... 253
The Corrosion of Iron as an Electrochemical Phenomenon..... 254
THE IRON AND STEEL MARKET..... 256
American Society for Testing Materials, Atlantic City Meeting.... 256
Toronto Meeting, American Chemical Society..... 257
CORRESPONDENCE:
The Townsend Cell for Chloride Electrolysis. By J. R. Crocker. 258
Manufacture and Uses of Carbon Tetrachloride. By J. R. Crocker.. 259
Iron and Steel Institute, Annual Meeting..... 262
Test of an Ozonizer. By Arthur W. Ewell..... 264
Metallurgical Calculations. (Copper.) By J. W. Richards..... 266
A New Shaking Device for the Chemical Laboratory. By J. M. Camp 270
The Effect of Stress Upon Corrosion of Iron. By Wm. H. Walker. 270
Héroult Electric Steel Process..... 272
NOTES ON ELECTROCHEMISTRY AND METALLURGY IN GREAT BRITAIN 275
ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS... 278
SYNOPSIS OF PERIODICAL LITERATURE..... 281
RECENT METALLURGICAL PATENTS 283
A Proposed Society of Chemical Engineers..... 285
Repairing with Thermit 285
Large Tube Mills in the Cyanide Process..... 286
Multimeter and Electroplater's Voltmeter..... 287
A New Portable Combination Meter..... 287
The Welding of Copper, Brass and Bronze by the Epurite Process. 288
Autogenous Welding with the Oxy-Acetylene Blow Pipe..... 288
Fertilizers from Atmospheric Nitrogen in America..... 289
A Portable Pyrometer for Instantaneously Taking Temperature of Molten Metals 289
Stoneware Cocks 290
NOTES 290
DIGEST OF UNITED STATES PATENTS. (Calcium Carbide)..... 292
NEW BOOKS 293
BOOK REVIEWS:
J. W. Richards' Metallurgical Calculations. Part II..... 294
C. H. Kuderer's Table of Volumes Through Air-Ways..... 294
M. LeBlanc, W. R. Whitney and J. W. Brown's Textbook of Electrochemistry 295
Ludwig Boltzmann's Populäre Schriften 295

Forty Years of Iron Furnace Growth.

During the first six months of this year there have been completed and blown in nine absolutely new blast furnaces, which have a rated capacity of 1,260,000 gross tons of pig iron per annum, having thus an average capacity of 140,000 tons each. Four of these are merchant stacks, which on account of the variety of grades they may be called upon to make, and for other reasons, are of relatively smaller capacity than the five steel works furnaces, two of these being rated at 200,000 tons each. The annual capacity of these nine furnaces, added to the producing ranks in a brief half-year, is greater than the total pig iron production of the United States in 1866 or in any previous year. In 1866 the United States produced 1,205,663 gross tons of pig iron. We have not absolutely accurate records, but have enough data to show that in 1866 there were more than 400 blast furnaces in the United States, which either produced pig iron during that year or had not been definitely abandoned. These nine new blast furnaces can make more pig iron than some 400 furnaces did only forty years ago. Blast furnace capacity is increasing very rapidly. Following the furnaces just completed there are furnaces now being built having a capacity of nearly 4,000,000 tons per annum. At the close of last year the United States was making pig iron at the rate of almost 27,000,000 tons a year, so that with furnaces since built, or which can be completed within a twelvemonth or so, there will be a capacity of very well over 30,000,000 tons a year. Excluding the relatively small charcoal stacks, there will be a productive capacity of 30,000,000 tons a year, by a smaller number of furnaces than forty years ago were required to make a million tons.

Developments in the Rail Trade.

Developments since our last issue illustrate quite clearly the correctness of our contention that the matter of rail quality is to a greater degree a commercial than a metallurgical proposition. It has developed that to fill the "Cassatt specifications," which the Pennsylvania Railroad believes will give it a satisfactory rail, the rail mills demand $5 a ton premium, making the price $33 f. o. b. mill. Meanwhile the Pennsylvania rail order for 1908 delivery is held up, although nearly two months ago it was announced that it had been placed for 142,600 tons. An inspired statement contains the following naive presentation of the situation: "These new specifications on the part of the Pennsylvania have caused no friction. Steel rail manufacturers say they will manufacture any kind of a rail a railroad wants, providing the road is willing to pay a reasonable price for it."

* * *

Doubtless the rail mills can do this within all probable limits, and undoubtedly they will do it, for a reasonable price, the rail mills, incidentally, being the judges of what is a reasonable price. Clearly, there is no metallurgical but a commercial problem presented, as we maintained a month ago. The Cassatt specifications call for the cropping of 25 per cent

from the top of the ingot, increased stringency in the drop test, limitation of the amount of cold straightening required, and some minor points. Liberal cropping is not a new feature; cropping has been reduced of late, because the mills were so anxious to get out large tonnages. From the beginning the drop test of the Southern rail maker has been much more severe than that of the Northern mills, and this must not be considered a feature of open-hearth steel rail manufacture in particular, but of rail manufacture in general.

* * *

The kink in the position of the rail mills is simply that through commercial developments in the past few years the quality of rails has gone down, while the price has been maintained at $28 through thick and thin. Now their position —a strictly commercial one—is that any departure in methods of manufacture must be considered on the basis of the most recent practice, with a "reasonable" increase in the price to pay for that departure. The $5 premium asked to fill the Cassatt specifications is obviously not based upon the increase in the actual cost of manufacture. It is not a question of shop costs, but of actual profits to be derived from operating a given plant or group of plants, when there is demand for all the material the plants can turn out. At present profits in steel manufacture are very large, and to reduce the output of a plant by but a few per cent, when demand equals or exceeds the previous capacity, makes a large reduction in ultimate profits. The 25 per cent crops can be remelted in open-hearth furnaces and cast into ingots at a very small cost. In the case of nearly all Bessemer rail mills the cost of transport to the neareast open-hearth plant would be very small. It is doubtful whether in any instance the output of the open-hearth plant would not be increased somewhat by this greater use of scrap. More Bessemer pig iron and less basic pig would have to be made, and that is probably where the rub comes, but if the steel industry is afraid of impoverishing its ore mines by mining too large a proportion of the lower phosphorus ores, it must increase its basic open-hearth steel capacity and decrease its Bessemer capacity. However, with the large increases being made in open-hearth capacity, and no change in Bessemer capacity except by the abandonment of that process at Duquesne, enough is probably being done to take care of that point.

The Corrosion of Iron as an Electrochemical Phenomenon.

In this issue we print abstracts of two papers on the corrosion of iron. One was presented by Dr. A. S. Cushman, of the Department of Agriculture, before the American Society of Testing Materials, and offers a new electrolytic theory of the corrosion of iron. The other, by Dr. William H. Walker, of the Massachusetts Institute of Technology, gives the results of an experimental investigation of the influence of stress on the corrosion of iron. Dr. Walker's paper can only be understood in the light of Dr. Cushman's theory, since what Dr. Walker has really measured is the influence of stress on the electrical potential of iron, so that direct proportionality between corrosion and electric potential (other fundamental conditions being equal) is presupposed. Dr. Walker's paper is acknowledged to be to a certain extent preliminary, but a careful study of the work done by him will bring out some very interesting points. Not only does he shake severely some results of former investigators, hitherto widely accepted, but the exceedingly careful and systematic method of his research emphasizes the great inherent difficulties of excluding all other influences but that of stress upon potential. The detailed account of his further researches should be awaited with great interest, since the results must be of immense importance for all engineering work using structural steel—if Dr. Cushman's fundamental electrolytic theory of corrosion is right.

* * *

Dr. Cushman's paper appears to have had a stunning effect on his audience, partly on account of the novelty of the theory, as proposed, to some extent at least in glittering paradoxes, and partly on account of the corroboration of the presented hypothesis by pretty and interesting lantern slides. On "the day after" we may coolly and critically dissect the argument and shall be pleased to find the theory sound, even if it is not found to be revolutionary. If we understand Dr. Cushman correctly, he has not suggested a purely electrolytic theory of the corrosion of iron. According to him there are two steps—the first is electrolytic, and results in a solution of iron, which thereby passes from the metallic into the ferrous ionic state; the second step is purely chemical, the oxygen in the atmosphere oxidizing the ferrous ion to ferric, and thus precipitating the insoluble red hydroxide known as rust. When Dr. Cushman makes the surprising statement that it is the hydrogen ions rather than the oxygen which are at the bottom of the rusting of iron, he evidently means only the first attack of the iron, whereby it is forced to pass into solution, and if we look at it that way there is nothing revolutionary whatever in his hypothesis. Take very pure zinc and put it into sulphuric acid, there will be practically no action, while if we use impure zinc we at once observe a strong evolution of hydrogen, zinc going simultaneously into solution. Instead of the impure zinc we may take very pure zinc and wind a few turns of platinum wire around it, the result being the same, the hydrogen being now developed at the platinum surface, while the zinc is dissolved. In the latter case we have a short-circuited galvanic cell or a galvanic couple, the zinc being the anode and the platinum the cathode, the chemical reaction being exactly the same as in the old Smee primary cell. Impure zinc behaves in exactly the same way, the only difference being that in this case the cathode—or rather, cathodes—are formed by the innumerable impurities distributed over the surface of the zinc; in this case the zinc is the seat of innumerable galvanic couples.

* * *

The reason why the zinc is dissolved with hydrogen development may be stated in different ways. On the basis of the old thermochemical views we may say that since the formation energy Zn, S, $O_4 = 248{,}000$ calories and H_2, S, $O_4 = 210{,}200$, we find that the reaction $Zn + H_2SO_4 = ZnSO_4 + H_2$ evolves 37,800 calories. According to Berthelot's principle of maximum work this reaction will go on spontaneously, because it evolves heat, and from Thomson's rule we find directly the electromotive force of the reaction to be 0.8 volt. We know that this way of looking at the matter is not strictly correct, but while the above consideration is wrong in principle, this method of calculation gives approximately correct results. To state the

principle correctly, we should not use Berthelot's rule, but the second law of thermodynamics. We should not say that the reaction goes on spontaneously because it evolves heat or (what is the same) because its total energy of reaction is positive. We should rather say that it goes on because its free energy (its capacity of performing work) is positive. However, the numerical values of the total energy and of the free energy are but little different in this case, as in most cases of practice at ordinary temperatures. Further, we should strictly apply the Helmholtz-Gibbs equation instead of Thomson's rule. But again, the numerical result is about the same. The easiest way of measuring the free energy is by measuring the potential. The potential of zinc against the hydrogen electrode is found to be 0.770 volt; in other words, the electromotive force corresponding to the free energy of the reaction which dissolves Zn with evolution of hydrogen is 0.770 volt (against 0.8 volt found above). Now we may go a step further and apply Van't Hoff's osmotic theory of solutions together with Nernst's theory of the solution pressure. By doing so, we remain strictly on the basis of the free-energy principle, but also make use of the analogy between the laws for the osmotic pressure in solutions and the pressure in gases. On this basis the reason why zinc goes into solution and hydrogen is set free is that the solution pressure of zinc overpowers the osmotic pressure of the hydrogen ions. The zinc will therefore pass into solution, but when doing so it assumes the ionic state, that means its atoms become electrically charged. Now these charges are taken over from the hydrogen ions, which therefore pass into the elementary state, the hydrogen being set free as gas or being plated out just as copper is plated out in electroplating. According to this view the solution of the zinc is the result of the presence of hydrogen ions and of the fact that the latter have a lower osmotic pressure than the solution pressure of the zinc.

* * *

We have dwelt at length on this familiar example of the dissolving of zinc in sulphuric acid, because nobody will find anything paradoxical or revolutionary in it. Yet the solution of the iron according to Dr. Cushman's hypothesis is to be considered from absolutely the same point of view. The iron goes into solution when hydrogen ions are in contact with it, because the solution pressure of iron is higher than the osmotic pressure of the hydrogen ions. There is only a quantitative but not a qualitative difference between the dissolving of iron and that of zinc. The energy of the reaction which produces an iron sulphate solution and hydrogen from sulphuric acid and iron is 24,700 calories on the basis of molecular weights, hence the corresponding e. m. f., according to Thomson's rule, is 0.5 volt. The measurement of the potential of iron against the hydrogen electrode gives 0.344 volt. If we simply substitute these figures for those which are valid for the solution of zinc we can repeat every word that was said concerning the latter problem in the preceding paragraph. It will now be understood that Dr. Cushman's statement of the hydrogen ions causing the rust must be taken *cum grano salis;* he simply means that when iron dissolves in moisture the hydrogen ions play a decisive rôle, while the formation of rust proper is subsequent, purely chemical, that is, non-electrolytic, and caused by the oxygen of the air.

In making use of his theory to prevent corrosion, Dr. Cushman points out that rusting will be inhibited if the preliminary solution of the iron is prevented. Strong alkali solutions will evidently do, since there are no hydrogen ions in the same, and the iron could not rob the alkali metal of its electric charge since the free energy of this reaction would be negative. Hence, iron will not rust in sufficiently strong alkaline solutions. A second and very interesting kind of rust inhibitors is found in strong oxidizing agents like the chromates and bichromates of potassium and sodium. This is another of Dr. Cushman's paradoxes, and is explained by him by the hypothesis that by the treatment with such reagents the iron electrode is brought into the state of an oxygen electrode. The most remarkable fact about this is that iron properly treated by this method remains permanently passive. While this is an established fact, there is something mysterious about the idea of thus producing an everlasting indestructible oxygen electrode, and we eagerly await further details on this point from the full account of Dr. Cushman's work to be published shortly as a Bulletin of the Department of Agriculture. As a whole, this work reflects high credit on its author and the Government department under the auspices of which it was done. If anybody should ask what rusting of iron has to do with agriculture, it may be explained that Dr. Cushman's work started with an investigation of the reasons underlying the rusting of fence wire. This first preliminary work was published in a Farmers' Bulletin a few years ago.

* * *

Dr. Cushman's theory suggests another thought. It is all true that the hydrogen ions play an important rôle in the dissolving of the iron, but the electrolytic action also requires some foreign material in the iron to act as cathode. Very pure zinc does not dissolve in sulphuric acid, because there are no impurities to act as cathodes, hence there are no galvanic couples. We might draw the same conclusion with respect to iron. Some corroboration of this thought may be found in some facts recorded in Dr. Cushman's fence-wire bulletin. It is a fact that with modern converter and open-hearth practice an absolutely uniform steel cannot be produced. Gases, oxides and slag cannot be entirely eliminated from the metal. To prevent pipes and blow-holes, which are mainly due to iron oxides dissolved in steel, the solution of iron oxides must be prevented, and for this purpose ferro-manganese and ferro-silicon are added. This is effective, because manganese and silicon combine with the iron, but the resulting oxides are solid and remain in the steel in a finely divided state. According to the present state of the art a uniform steel free from impurities can only be produced by the crucible process or in the electric furnace. The crucible process is out of the question for general purposes. But if an electric furnace process for steel refining, such as that of Héroult, can be carried out as cheaply as is claimed by its inventor to produce a uniform metal, it would certainly be worth while to test experimentally the liability of such metal to corrosion. From Dr. Cushman's theory we should expect such metal to be much more resistant to corrosion. If this is true electric furnace treatment might be found in the end to be the cheapest preventive against rusting. While this is offered only as a tentative suggestion, it should be worth while to subject it to experimental tests.

The Iron and Steel Market.

The iron and steel market became extremely dull early in June, and the most important observation that can be made now is that it has stood this dullness very well, indeed. Prices of finished steel products have shown absolutely no recession, while in pig iron the chief change has been that the abnormally heavy premiums which were being charged for small lots for prompt delivery have been reduced. The market for crude steel has declined perhaps a dollar a ton, but was abnormally high relative either to pig iron or to finished steel products.

The sentiment which has pervaded the iron and steel consuming trades during the past fortnight has been practically without precedent. There has been a marked indisposition to make fresh purchases but with no desire to cancel or postpone shipments upon previous obligations. Hitherto when buyers ceased making new commitments they began to try to evade some of their previous commitments, but that is not so in this case. There is almost as much pressure as formerly for deliveries, and furnace and mill capacity continues to be pushed to the limit. The contention so often made of late has been proved to be true, that the large volume of business on the books of furnaces and steel producers is of a vastly sounder nature than ever before. There was a time when purchases of finished steel products represented little more than options in favor of the buyer, but it is not so now.

Without a further large buying movement the iron and steel industry can operate at full pressure well into the fourth quarter of this year. It is quite possible that such a buying movement will be inaugurated; if it is not, then there will be a decided hunger for orders before this year is out, a hunger which cannot readily be appeased as capacities have grown wonderfully in this period of extreme activity, which has lasted nearly three years. It was difficult, with the then existing capacity, to make 23,000,000 tons of pig iron in 1905, but the middle of 1907 finds a capacity well over 27,500,000 tons, and much additional capacity still in course of erection.

Pig Iron.

The market has been very quiet. The chief tonnage has comprised a few sales of Northern and Southern iron for delivery in the first half of 1908, and some resales of pig iron, originally purchased by Milliken Bros., who failed, and whose steel plant on Staten Island has been closed indefinitely. For this failure the heavy advance in pig iron in the past three years, relative to finished steel products, is directly responsible. The steel plant should not have been built without blast furnaces and an adequate supply of ore. Blast furnaces are fairly well sold up for the balance of the year, and a quiet market is to be expected for several months unless the market for 1908 delivery should open up in a large way. The fancy prices for small lots for prompt delivery have largely disappeared. For third quarter delivery there has been a slight recession, but fourth quarter prices are substantially unchanged. The market f. o. b. Mahoning or Shenango Valley furnace (90 cents higher delivered Pittsburg) is substantially as follows for second half delivery: Bessemer, $23.25; basic, $23.00; No. 2 foundry, $23.00; gray forge, $22.00; Southern, No. 2 foundry, f. o. b., Birmingham, is about $20.00 for second half, with $18.50 quoted for first half of 1908.

Steel.

Early in the month two or three steel mills concluded to market a larger portion of their product in the form of billets, taking the supply chiefly from their structural mills. The largest seller has marketed between 40,000 and 50,000 tons of billets through following this policy. The Steel Corporation has not appeared as a seller, being still under pressure to carry out prior obligations. The market has receded but slightly. Bessemer billets can be had, delivered Pittsburg, at $30, with open-hearth billets at $31.00 to $32.00. As the sellers are located outside of Pittsburg, delivered prices are not necessarily the Pittsburg price, plus the freight from Pittsburg, an alignment which has much prevailed in the recent past. On June 20 the Carnegie Steel Co. made its usual announcement as to the price of sheet bars on monthly and quarterly adjustment prices, naming the price for July and third quarter deliveries at $31.00, Pittsburg, for long bars. The June price was $31.00, while the second quarter price was $30.00.

Rails.

Our last report noted that some 700,000 tons of rails had been booked for 1908 delivery. The total included the Pennsylvania requirements of 142,600 tons, but since then it has developed that the announcement that the Pennsylvania order had been placed was based upon an expectation that arrangements as to specification would be made, an expectation which thus far has not been justified, since the rail mills have asked a $5.00 premium to fill the "Cassatt specifications," and the Pennsylvania order is hung up. Some additional business has been booked, and without the Pennsylvania order the total booked by all mills is now stated to be about 800,000 tons for 1908 delivery, of which some 300,000 tons comprises open-hearth rails booked by the Southern interest, almost its total capacity for the year. Demand for light rails is extremely good.

Finished Materials.

New business has materially fallen off, but there is still great pressure for deliveries. In nearly all lines mills are making much better promises for delivery of material on new orders than they were a month ago, and the gain in promises cannot be due entirely to heavy production, but must be due in large part to a more modest estimate of the requirements of customers who have long-time contracts and merely specify from time to time.

There have been no changes in prices, which stand as follow for regular mill delivery, all f. o. b., Pittsburg, plus freight to destination: Structural shapes, $1.70 for beams and channels, 15 inches and under.

Plates, $1.70 for tank quality.

Merchant steel bars, $1,60, base.

Common iron bars, $1.70, delivered Pittsburg; for Western delivery, $1.60, f. o. b. Pittsburg.

Sheets, 28 gauge, $2.60 for black, $3.75 for galvanized.

Tin plates, $3.90 for 100-pound cokes.

Freight rates on finished steel products generally, the list not including tin plates, were advanced June 1 1½ cents a hundred pounds from Pittsburg to the chief points, being now 18 cents a hundred to Chicago, 15 cents to Philadelphia, 14½ cents to Baltimore and 16 cents to New York.

American Society for Testing Materials.

The tenth annual meeting of the American Society for Testing Materials was held at Atlantic City from June 20 to 22. The convention was the best attended one in the history of the society, the number of members and guests who registered being 268. From the annual report of the executive committee it appears that the number of members has increased during the last year from 835 to 925.

The first paper presented on Thursday afternoon, June 20, dealt with business methods in the purchase of the different raw materials for a large manufacturing company, Messrs. P. H. Knight and C. E. Skinner, of the Westinghouse Electric & Manufacturing Co., being the authors. Papers concerning the purchase of coal by the United States Government and methods of sampling and testing were presented by Messrs. J. E. Woodwell, D. T. Randall, S. S. Voorhees, H. M. Wilson and R. Moldenke. The yearly coal bill of the United States Government is $6,500,000.

Mr. Robert Job presented a paper on causes of failure of cast iron in service. In his experience he has found in many cases that the difficulty was due wholly or in large part to the pres-

ence of blow-holes or to porosity or sponginess of the iron and at times to the presence of considerable proportions of oxide of iron and cinder in the iron. By introducing strict specifications for the supply in the foundry with which he is connected and also introducing new methods of treating the iron in the ladle and in the cupola, so as to remove oxide of iron and blow-holes and to increase fluidity and density, he was able to achieve excellent results.

In the evening Dr. C. B. Dudley presented his presidential address, which dealt with the enforcement of specifications.

Besides various papers relating to concrete the paper of W. H. Walker and C. Dill on the influence of stress upon the corrosion of iron was read. It covered the same ground as their recent paper before the American Electrochemical Society. A full account of the results obtained by the author will be found on another page of this issue.

THE CORROSION OF IRON AN ELECTROLYTIC PHENOMENON.

Dr. A. S. CUSHMAN, of the United States Bureau of Agriculture, discussed in an able paper the corrosion of iron. He explained why neither the carbonic acid theory nor the hydrogen peroxide theory could be regarded as adequate explanations of the rusting of iron. He presented a new thory, which considers the rusting of iron as an electrolytic phenomenon. Oxygen is not the primary cause of rusting, but hydrogen ions. The rôle of oxygen is only secondary. What really always happens when iron rusts is this: there is some short-circuited galvanic cell (due to impurities contained within and distributed throughout the iron) and hydrogen ions are set free, iron passing into solution as a ferrous ion and replacing the hydrogen. The ferrous ion is then oxidized by the oxygen in the air to ferric, and the formation of a hydrated oxide results.

All soluble inhibitors of rusting act in either of the following two ways: Alkaline solutions prevent rusting because there are no hydrogen ions in alkaline solutions. Chromic acid and its salts, which are strong oxidizing agents, prevent rusting on account of the formation of an oxygen film (not an oxide film), so that the iron becomes polarized in the sense of becoming an oxygen electrode. The author stated that a solution of potassium bicromate, not stronger than 1/600 normal, will indefinitely prevent the rusting of polished specimens of metal in cold water, even if free access of air and carbonic acid is provided for. If iron in any of its forms is immersed in strong solutions of bichromate for a few hours the surface becomes passive, even after it is removed from the solution, washed and wiped.

Since the rusting of iron is the result of the existence of galvanic couples, electric potential differences exist, and the places of cathodes and anodes can be made visible by means of a special indicator which is called by the author "ferroxyl." Agaragar and gelatin jellies impregnated with phenol phthalein and potassium ferricyanide show red and blue nodes on specimens of iron and steel imbedded in them; the blue nodes appear where the iron is anode and is passing into solution, while the red nodes indicate cathodes. If a certain point continues to be anode for a length of time pitting occurs. The author urged that experiments should be made to try the prevention of iron rust by means of bichromate on a practical scale.

RAIL METAL.

The section meetings of Friday morning dealt with matter relating to cement and to preservative coatings and paint films for metal surfaces. The session of Friday afternoon was the best attended of the whole meeting, on account of the announced discussion of new specifications for steel rails and of the troubles with rail metal. It had been expected that there would be some sharp words, but the discussion turned out to be rather a love feast, almost every speaker being satisfied with urging a stronger and heavier rail section. While for several years the railroad and the steel works members of the committee on iron and steel of the association had been unable to agree as to a rail specification an agreement has now been reached and the proposed standard specifications for steel rails will be submitted to the membership by letter ballot.

Dr. H. M. Howe, in a paper on segregation in steel ingots, discussed the question whether low-sulphur content does lessen the segregation of carbon. If low sulphur does this this fact would increase the value of the thorough desulphurizing which certain electrical processes, such as the Héroult process, bring about. Segregation is often thought of only as concentrating the sulphur and phosphorus harmfully in the upper part of the axis of the ingot, and in case of low-carbon steel this is indeed its chief reproach. But in case of high-carbon steel, segregation does the further harm of giving great irregularity of carbon content. If these electrical refining processes not only expel sulphur thoroughly, but thereby prevent or lessen the segregation of carbon, this is so much to their good. Dr. Howe has examined all available cases of segregation, about 100 in number, and the evidence of his investigation tends to show that low-sulphur content does not tend to restrain the segregation of carbon.

On the evening of Friday a complimentary dinner was tendered to the distinguished president of the society, Dr. C. B. Dudley.

At the Saturday sessions the committees on standard specifications for stay-bolt iron, on uniform speed in commercial testing and on standard methods of testing presented their reports, and papers on kindred subjects were read.

Toronto Meeting of the American Chemical Society.

The thirty-sixth general meeting of the American Chemical Society was held at Toronto, June 27-29, about 120 chemists being in attendance.

The Society was most royally entertained by the University and city of Toronto. Complimentary lunches were furnished by the University, and several garden parties and smokers contributed greatly to the enjoyment of the visiting members.

Saturday was given to an excursion to Guelph, to visit the Agricultural College.

Following the meeting on Saturday a train carrying about fifty of the members left for a three days' trip to the new mining region of Cobalt.

In addition to the general sessions of the Society there were meetings of the sections of Physical, Inorganic, Organic, Agricultural, Sanitary and Biological and Industrial Chemistry. The chairmen of the several sections presented addresses before the general sessions.

Prof. W. H. Ellis, of the section of Industrial Chemistry, was taken seriously ill just before the meeting, and was unable to be present, much to the regret of every one present.

Prof. Bancroft, of Cornell University, gave an address on "Measurement of Chemical Affinity."

Frank T. Shutt spoke of "Chemistry and Canadian Agriculture," referring especially to the losses of nitrogen which virgin soils undergo on cultivaion and means which have been developed to prevent any such loss.

Dr. J. Bishop Tingle, recently appointed professor at McMaster University, spoke of "American Chemical Research," especially of the development of research as indicated by the volume of publications, which remained practically stationary from '79 to '89, while it doubled in the following decade and has become, at least, three times as great during the last eight years.

Prof. C. L. Parsons, of Durham, N. H., spoke of "The Vagaries of Beryllium," a subject in which he has been especially interested and upon which he has done excellent work.

Mr. E. G. Acheson presented a paper on "Deflocculated Graphite," illustrating his address with experimental demonstration. Experiments on clays, carried out in the year 1901,

showed that by adding vegetable extracts—gallotannic acid, extract of straw—to moderately plastic weak clays, their plasticity was increased, the amount of water required to produce a given degree of fluidity was lessened, and the size of the particles in suspension was much reduced. The effect on finely divided graphite is much the same; and by the use of a little gallotanic acid and a few drops of ammonia, suspensions may be prepared which last indefinitely. Extensive tests are now being made to determine the value of this "deflocculated graphite" as a lubricant, with most encouraging results.

More than eighty papers were presented before the various sections of the Society, and abstracts of the same had been printed in advance in a very handy pamphlet, from which we take the following:

A paper by S. Avery and Mildred Parks dealt with the fixation of nitrogen in moist air by the silent electric discharge. The writers review the work of Berthelot, who concludes that the action is a catalytic one to be expressed as follows: $N_2 + H_2O + 5O = 2HNO_3$.

He lays special emphasis on the fact that no nitrous acid is formed. Following in part the work of Berthelot but working for shorter periods and using the Griess test for nitrous acid the writers found about one-tenth of the fixed nitrogen present as nitrous acid. The longer the action the less was the proportion of nitrous acid present. Any agent capable of absorbing ozone, as a piece of rubber placed in the field of the discharge, enormously increased the proportions of nitrous acid; but the observation is inconclusive as nitric acid might be reduced as well as ozone absorbed. Conducted at a temperature high enough to destroy ozone, nitrous acid is found abundantly in the cooled products. but this is also inconclusive.

If a solution of nitrous acid as formed above be treated for some time with air containing ozone but no oxides of nitrogen, every trace of nitrous acid disappears.

While the results obtained are not entirely conclusive, the writers are strongly inclined to the opinion that the formation of nitric acid is due to the oxidation of lower oxides by ozone in the presence of water.

A paper by S. A. Tucker described a platinum-resistance furnace for melting points and combustions. It consists of a quartz tube, heated by a spiral of platinum tape, the whole being surrounded by infusorial earth enclosed in an asbestos box. Most excellent results on combustions and on the determination of melting points were obtained in this apparatus.

A paper by Saul Dushman dealt with copper as anode in chloride solutions. Increasing the concentration of the chloride, or rotating the anode, increases the proportion of cuprous salt formed. The experiments are in agreement with the supposition that cuprous and cupric salts are formed in such proportions that the solution at the surface of the anode is in equilibrium with metallic copper.

A paper by J. C. W. Frazer and H. N. Holmes gave the results of an experimental investigation of electric osmose. One of the conclusions reached by them from the investigation of a limited number of solutions is that the osmose for a given amount of current varies inversely as the velocity of the cation divided by its valence.

A paper by Harrison E. Patten deals with the effect of suspended particles upon the conductivity of a solution. It is shown experimentally that soil suspended in alkaline carbonate solution absorbs the electrolyte, and consequently when the soil particles are removed from the solution by centrifugal force or by settling, this absorbed electrolyte is carried down and removed from contact with the main body of the supernatant solution, whose electrical conductivity is thereby lowered to a marked degree. When these soil grains with their absorbed electrolyte are again stirred into the solution and resuspended, the conductivity of the liquid and particles is higher than that of the supernatant solution. This experiment indicates that the absorbed material is in solution, since it contributes to the electrical conductivity.

CORRESPONDENCE

The Townsend Cell for Sodium Chloride Electrolysis.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—I note in the June issue of your journal a very interesting paper by Dr. L. Baekeland, describing the Townsend cell, and in reviewing the same my attention has been particularly attracted towards the high efficiencies claimed both in energy and current. These claims are made on such a basis as to excite my curiosity as to the method of their calculation.

It is a fundamental fact that the decomposition of sodium chloride requires 97,900 calories, while a dilute solution requires 96,600 calories, taken on the basis of molecular heat of formation, and since the electrical unit of energy is the Joule, equal to .238 calories, the number of joules necessary for the decomposition of sodium chloride into its constituents is 405,882 joules. Again, since the molecular weight of sodium chloride is 58.5, and 1 coulomb will decompose .0006045 grams of sodium chloride, there will be required for the 58.5 grams 96,540 coulombs, thereby requiring a vital voltage of at least 4.2 volts. This calculation is made on the supposition of direct electrolytic decomposition of sodium chloride in a comparatively dry state, and considering the matter from this standpoint it is theoretically possible to secure the highest efficiency, but it is impracticable on account of the tremendous amount of heat lost through radiation.

If the subject is viewed from the standpoint of a diluted solution, the electrolyte is bound to become a more complicated proposition. For instance, while in the first case where chlorine gas and sodium are set free the decomposition is direct, yet if the electrolyte is a dilute solution the decomposition takes place as follows:

$$NaCl = Na + Cl$$
$$H_2O + Na = NaOH + H.$$

Working on the basis of this formula. the calories necessary for the decomposition of NaCl is 96,600, the calories for H_2O are 69,000, and the calories for NaOH are 112,500. Hence, for the formation of chlorine gas, hydrogen and a caustic soda solution 53,100 calories are required. Since this figure corresponds to the passage of 96,540 coulombs, the vital voltage required is 2.29. This voltage is the pressure required for the decomposition of sodium chloride into chlorine gas, hydrogen and caustic soda. To this voltage must be added that necessary to overcome the resistance of the cell and especially that offered by the diaphragm in all cells of this character.

From "Fig. 6, Efficiency Curves" in the article, I note that the voltage necessary for the operation of the cell is quite close to 5 volts, and allowing for the high-current efficiency the writer is unable to understand how an energy efficiency averaging in the neighborhood of 68 per cent can be acquired. I should say that this should be nearer 45 per cent.

With reference to the ampere-hour efficiency, which according to the curve, I should judge to average about 98 per cent, I am unable to verify this, since the output of the cell is not mentioned. But my experience has been that under ordinary conditions it is exceptional to secure an average of 90 per cent efficiency in a diaphragm cell. Another feature which must not be overlooked is that if a high-current density is used there is bound to be quite some evolution of heat. This naturally cuts down the efficiency. I would be pleased to hear what the output of these cells is under various current densities. In that way I could verify the current efficiencies.

Another point which I note is that there is a considerable amount of salt carried over through the diaphragm. Naturally, the solution containing the salt in such large quantities requires a considerable amount of work in the vacuum pans, and unless the pans are properly constructed the salt solution with the caustic soda will have a deterimental effect upon the tubes.

J. R. Crocker.

New York City.

Manufacture and Uses of Carbon Tetrachloride.

BY J. R. CROCKER.

Carbon tetrachloride as a solvent has been well known to the practical chemist for a number of years, but its entrance into the commercial field has been delayed mainly by its high first cost, and, secondly, by the lack of information with sufficient proofs as to its adaptability on a commercial scale.

The recovery system in the oil, wool, fertilizer and packing house industries has arrived under the present methods at the highest point of perfection. Therefore, further improvements can only be obtained along the line of using a solvent of greater efficiency. Carbon tetrachloride has been looked upon as a possible relief in this direction. It has to its advantage over benzine and naphtha (the most common solvent at present) its ability to extract the desired product more proficiently, both in purity and brevity of time.

It is a clear, colorless liquid (sp. gr. 1.604) with an agreeable aromatic odor, free from inflammability and explosiveness, and it is known that its vapors extinguish flame. (Boiling point 78° C.) This feature is one that would meet with favor, especially where the State and Municipal laws governing fire risks by the use of benzine and naphtha are items of moment in the installation of an extracting plant.

Numerous experiments have been made on the ability of carbon tetrachloride to dissolve oils, fats, resinous pitch, coal tar, pine tar, rubber, salicylic acid, carbolic acid, bromine, iodoform, bromoform, menthal, camphor, naphthaline, sulphur chloride, soda and potash, ammonia, soaps and numerous other chemical products. As an extracting medium it shows remarkable ability in its action on fats, oils from oil seed, oil cake, animal tankage, wool, cotton and other fat-bearing materials.

Up to the present time there is, so far as the author knows, no system where its efficiency on an economical scale has been worked out on a commercial basis to prove its advantages over benzine and naphtha. What practical knowledge has been secured up to the present time has given it due credit for its great solvent powers, but its excessive cost has hindered it being taken up seriously by the manufacturers. Therefore, a few points will have to be settled definitely, and to the satisfaction of the would-be consumer, before he is convinced of its adaptability over the present solvents now used. I will endeavor to put forth a few of these points.

While carbon tetrachloride will extract fats and oils quite readily in a much shorter time, and secure a much better product thereby than by the use of naphtha and benzine, there is some doubt as to the possibility of extracting the last traces, or enough, so as to make the cake from the oil seeds or fat-bearing products free from carbon tetrachloride. This is especially so where oil seed is afterwards used to feed cattle. This feature is not only one of vital importance as to the efficiency of the use of the solvent, but the excessive cost in replacing the carbon tetrachloride loss. The amount of the solvent lost in this way with the present price of carbon tetrachloride should not exceed 2 per cent, otherwise the total cost of extracting, even considering the saving both in time and labor, is more than counteracted by this loss.

It has not as yet been shown that the present users of benzine, naphtha or carbon bisulphide can safely substitute without undue alterations in their present plants the carbon tetrachloride, nor is it well known what effect carbon tetrachloride will have on the evaporators, filter presses and other machinery where the solvent in whole or part comes in contact. Take for example a film evaporator, such as the Yaryan, which at the present time is used almost entirely in the oil, grease, fat and glue business, and under conditions where benzine or naphtha is used working most satisfactorily. It would remain a question what effect carbon tetrachloride would have upon its iron or brass parts. This might be said equally so of the other machinery used in the extraction. This query has resulted in a large number of experiments being made as to the adaptability of the metals to withstand the corrosive effect of the solvent. I will set forth a few experiments made upon a small scale and their effect upon different metals.

Steel, cast iron and wrought iron are only slightly effected by carbon tetrachloride; but the presence of moisture causes decomposition, especially where the solution is in rapid circulation, and if, with the rapid circulation there is an increase of heat, the decomposition takes the form of oxide of iron and a ferric chloride. This is quite marked if the moisture is excessive; but to exclude all moisture is practically impossible. This brings up the point that carbon tetrachloride should be as near anhydrous as possible, otherwise the effect of the moisture, as explained above, will readily attack the system throughout, especially where there are a large number of joints.

It has been suggested that lead-lined or tin apparatus be used, but considering the design and construction of the machinery of an extracting plant this would not be practical. Of course, there is a tendency of the free acid fats to exert their influence towards corrosiveness. Lead, lead-antimony alloys and tin resist carbon tetrachloride under varying conditions. Copper and its various alloys and bronzes, german silver, gun metal, etc., stand the action of carbon tetrachloride, but if the temperature is high the action is marked. Zinc and alumina will stand fairly well, nickel about the same as copper; but the presence of moisture, especially if at a high temperature, is most deteriorating to all these metals. It has been found that lead and tin offer the best protection.

Although much of the above information has been collected from small experiments, there has not up to the present time been an installation upon which a sufficient amount of information of a practical nature could be secured.

However, one of the redeeming features in the use of carbon tetrachloride is the relief from fire risk, as mentioned above. This in itself will greatly aid in future research, with the idea of its introduction as a substitute for the other solvents. Again, the question of cost will be one to be thoroughly proven. Whether carbon tetrachloride at high cost and its great solvent powers, curtailed by losses during its use, can supersede the solvents now used, with their low cost but lower efficiency and danger of fire, remains to be solved by actual practical operation on a reasonable scale.

Therefore, one of the principles on which will depend the future success of carbon tetrachloride on a commercial basis will be its low cost. At its present value and with the lack of more definite knowledge as to its possibilities, the future is open for a wide and interesting line of investigation. As will be readily appreciated, the prime cost of carbon tetrachloride is governed by the cost of chlorine gas, whether direct electrolytic methods are used or chemical and electrochemical are combined.

Several attempts have been made on a small scale to produce carbon tetrachloride by the introduction of an excess of chlorine in conjunction with Dutch liquid ($C_2H_4Cl_2$) by the influence of either sunlight or artificial light approaching sunlight, and in conjunction with heat and pressure. The object was to drive off the hydrogen molecules ($C_2H_4Cl_2 + Cl_8 = C_2Cl_6 - 4HCl$); the idea being that by the introduction of an excess of hydrogen aided by heat the violent turbulation thereby would cause an excess quantity of hydrogen to remain in a nascent state in the liquid, causing an additional amount of chlorine to combine with the carbon. For it is quite necessary that there should be sufficient hydrogen to be substituted for an equal quantity of chlorine, it being a well-known fact that the chlorine will invariably replace a part or a whole of the hydrogen.

The supposition was based on the following formula: $C_2H_6Cl_2 + Cl_{10} = 2CCl_4 - 4HCl$. Experiments along this line were conducted for sometime, both with Dutch liquid and March gas (CH_4), the March gas producing an oily mixture formed under the influence of sunlight. This oily mixture was found to con-

tain both carbon tetrachloride and chloroform, but through the greater activity of the hydrogen atoms and its unstable condition the final results proved unsatisfactory.

Another point before passage on this particular experiment, it was found that the best method to introduce the hydrogen into the Dutch liquid was under a high pressure and temperature of steam. the finely divisible water molecules coming in contact with the sluggish Dutch liquid and the excess of chlorine caused the formation of $HCl + C_2H_4Cl_2 = C_2H_6Cl_4$ and $C_2H_6Cl_4 + Cl_{10} = 2CCl_4 + H_6$, the hydrogen passing off as a free agent, therefore, direct combination was abandoned.

Another peculiarity about chlorine is that wherever heat is in contact with chlorinated carbon the chlorine is readily dispelled unless extra precaution is used to control and condense the escaping vapors. This is quite apparent by the reduction of trichloride of carbon (C_2Cl_6) to dichloride of carbon (C_2Cl_4) and to monochloride (C_2Cl_2).

Other methods of producing carbon tetrachloride have been introduced and tried both on a large and a small scale. In this country the carbon bisulphide process has been worked on a large scale, and attracted both producers and consumers here and abroad. I will endeavor to give a short description of same together with sketch.

It is a well-known fact that carbon tetrachloride is readily obtained by passing chlorine gas over heated carbon bisulphide (CS_2) and condensing the product in a cooler. A mixture of carbon tetrachloride and sulphur dichloride is obtained ($CS_2 + Cl_8 = CCl_4 + S_2Cl_2$), and by introducing caustic or potash into the mixture the sulphur dichloride is decomposed and dissolved, the carbon tetrachloride separating and falling to the bottom of the receptacle, being afterwards purified by distillation.

An equipment to produce carbon tetrachloride under the following formula is illustrated in Fig. 1 and described herewith.

As must be readily appreciated the chlorine gas must be as dry as possible before introduced into the presence of carbon bisulphide. To insure this the gas is first passed over sulphur, or diluted sulphuric acid and sulphur, whereby most of the moisture is extracted. The idea of introducing sulphur is not only for drying the gas but to likewise secure sulphur chloride. By this operation it is possible to secure an additional marketable product at an extremely low cost. By referring to the sketch the process can be readily followed.

The chlorine gas is introduced in pipe "A" under a slight suction. It might be well to mention that the gas can be secured either by chemical process or the more modern electrolytic process.

Passing through this pipe the gas is introduced into chamber "B" over partition "C" into chamber "D" up through tower "E," fitted with perforated plates, the gas then passing from this tower at its upper end to tower "F," descending to chamber "G," leaving through the pipe "I." The pump "H," being of a ball-piston type, carries the chlorinated sulphur liquor from the chambers "B," "D" and "G," which are connected, and distributes the same to the top of the towers in equal proportions, thereby causing a continuous circulation of the chlorinated liquor against a steady stream of the chlorine gas. As can be appreciated, after the gas has passed through this apparatus it has been thoroughly dried, and again the liquor can be circulated until it has received the proper amount of chlorination for sulphur chloride. The action will be as follows:

The chlorine gas coming in contact with the sulphur produces S_2Cl_2, the color and grade being governed by the amount of chlorine introduced. This chloride is exceedingly unstable when exposed to the sunlight. Sulphur chloride is used at present in the rubber industry in vulcanizing.

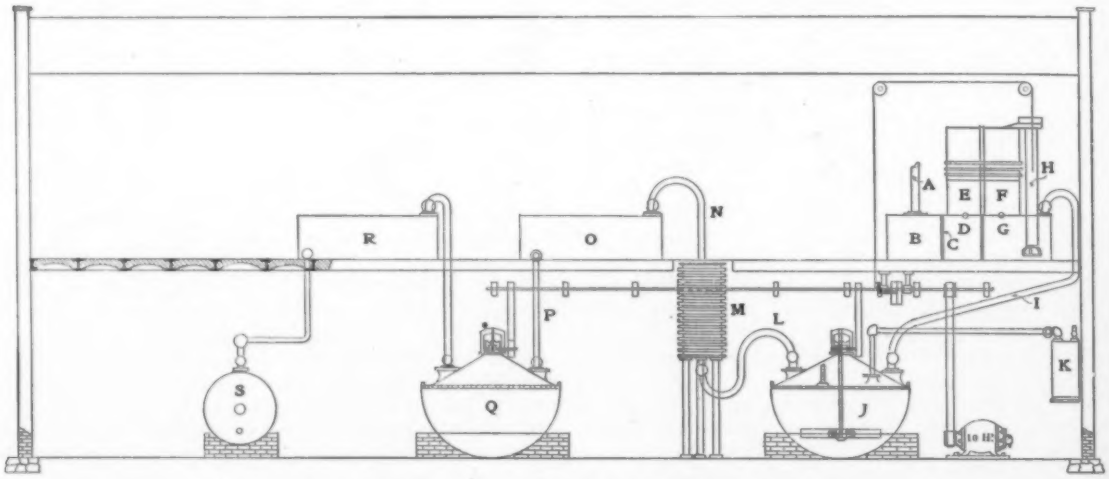


FIG. 1.—APPARATUS FOR THE PRODUCTION OF CARBON TETRACHLORIDE.

When the chlorine gas leaves the chamber "G" and passes through the pipe "I" it is brought into the caldron "J." The gas is received in this receptacle at an even and steady flow. There is likewise introduced into "J" the proper proportion of carbon bisulphide from the tank "K." It might be well to mention at this point that tank "K" acts more as a measuring tank, and it is quite advisable that the supply of carbon bisulphide located at this point be as limited as possible, since the high explosive conditions surrounding this compound would be detrimental.

To assist in the combination of the chlorine and carbon bisulphide in the caldron "J," it is fitted with an agitator driven by a line shaft located in the immediate vicinity. The caldron is also located upon a suitable foundation, so constructed as to facilitate the introduction of a heating apparatus. By the joint action of the agitator and the heating effect the chemical reaction is greatly facilitated. The regulation of the action is properly recorded by a thermometer introduced into the top of the caldron.

Immediately upon the formation of the tetrachloride gas, carrying with it a quantity of sulphur chloride, it passes through the pipe "L" into the bottom of a specially constructed catch-all "M." The object being to retard the entrainment of the liquors from "J." The gas then passes through the pipe

end into condenser "O," composed of several coils of lead pipe surrounded by cool water. The condensed gases leaving the condenser through the pipe "P" to the purifier "Q" are thereby treated by either caustic soda or lime to precipitate the sulphur chloride and impurities. This purifier is likewise fitted with an agitator.

Upon treating the solution with the alkali and drawing off the precipitate and reagitating, the gases given off are again condensed in condenser "R" of a construction similar to condenser "O." The clear anhydrous carbon tetrachloride passing from this condenser to storage tank "S" is a finished product.

As will be noted, the two products secured by this process, namely, sulphur chloride and carbon tetrachloride, are produced by the introduction of chlorine, sulphur and carbon bisulphide. Indeed, the sulphur secured from the precipitate in "J" is theoretically sufficient in quantity to be used in drying the gas in the towers "E" and "F," and producing a reasonable quantity of sulphur chloride. The reader will appreciate the fact that it is quite essential that a good pure supply is secured at the point "A." The flow of this gas through the apparatus is aided by the action of the condensing of the gases in both condenser "O" and "R."

To secure a good even flow of chlorine gas the author recommends the use of a substantial electrolytic cell, which by the decomposition of sodium chloride there will be secured both chlorine and caustic soda. The caustic soda secured still further simplifies the process by being used in the purifier as the precipitating agent in the purification of the carbon tetrachloride.

Numerous electrolytic cells have been brought to the attention of the author, who has found by a large number of tests that the points of economy both in operation and maintenance are readily secured by the McDonald cell. The author has been able to secure photographs illustrating an installation of seventy-five of these cells, which shows quite well the compactness of a plant capable of producing 1,500 pounds of chlorine per day of 24 hours, and about the same amount of caustic soda. As will be noted by referring to Fig. 2 the general arrangement of the cells facilitates their manipulation with a minimum amount of labor. In fact, a plant of this character can be operated for full 24 hours by two men. By again referring to the photographs it will be noted that the chlorine is taken from the rear end of the cells through an ordinary tile pipe, where it can be readily conveyed to the carbon tetrachloride plant under a slight suction.

FIG. 3.—POWER PLANT FOR ELECTROLYTIC CHLORINE WORKS SHOWN IN FIG. 2.

Another method of producing carbon tetrachloride has been recently patented and appears to be quite feasible. The reaction rests upon the direct introduction of bleach and carbon into the vicinity of a strong electric current, the gas secured being introduced into a chamber for the purpose of condensing volatile compounds, which may be carried over from the furnace by reason of the great heat and chemical action. From there the gas passes into an ordinary condenser, leaving the same as carbon tetrachloride. The chemical reaction is best explained by the formula

$$2CaCl_2 + 5C = CCl_4 - 2C_2Ca$$

It is suggested by the author that if a very low grade of calcium chloride is used and that if chlorine gas was introduced into the effect of the fusing current at approximately the same time as both the carbon and calcium chloride come under its influence, the efficiency of this process would be materially increased. If a process of this character could be made a success it would undoutedly be far superior to the carbon bisulphide process, as a clear solution of carbon tetrachloride would be readily secured at first hand with a minimum expenditure both in first cost of apparatus and maintenance thereof.

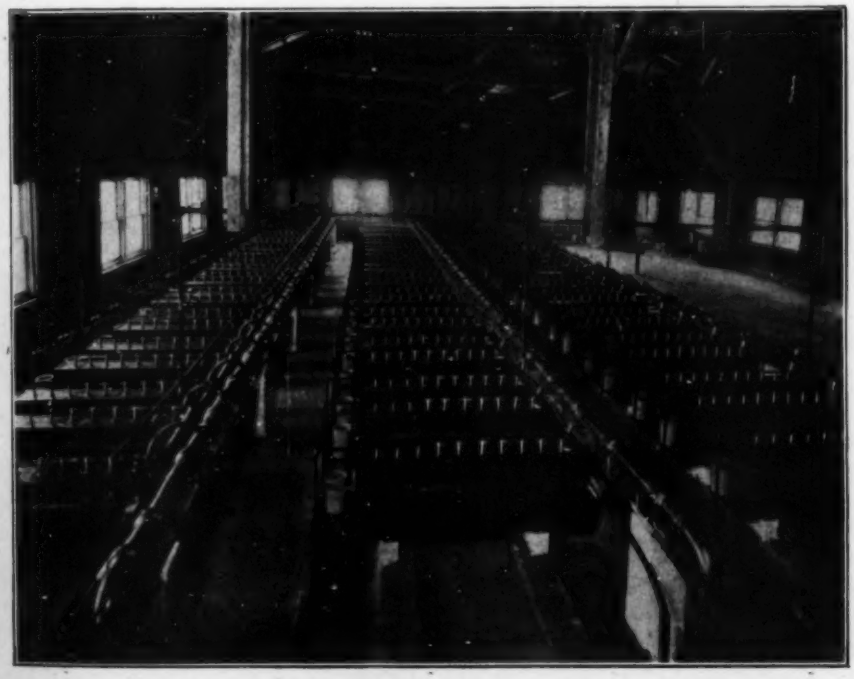


FIG. 2.—ELECTROLYTIC CELL FOR PRODUCTION OF CHLORINE AND CAUSTIC SODA OF UNITED STATES REDUCTION & REFINING CO., IN COLORADO.

Welding. — An interesting paper on the welding of structural materials in place was presented by Harry Arthur Ruck-Keene at the recent Engineering Conference of the (British) Institution of Civil Engineers. The author gave a concise outline of three methods of electric welding. of processes using the oxy-acetylene and oxy-hydrogen flame and of the aluminothermic process, with brief notes on applications of the different methods in practice.

Iron and Steel Institute.

As noticed in our last issue the annual meeting of the Iron and Steel Institute was held in London on May 9 and 10. We herewith give abstracts of part of the papers. An account of the discussion will be found in the monthly letter of our London correspondent.

Electrically-Driven Reversing Rolling Mills, by D. Selby Bigge. Although this paper has the more ambitious title of "The Development of Electricity in the Iron and Steel Industries," it deals entirely with reversing rolling mills operated on the Ilgner system at the Hildegardehütte of Trzynietz in Austrian Silesia. The essential feature of this system lies in its fly-wheel converter sub-station, where one three-phase induction motor drives two direct-current generators, and also two heavy fly-wheels which take the momentary peak loads. The fly-wheel effect is secured by the automatic insertion of a water resistance in the rotor circuit of the main motor. The rolling mill itself is driven by three direct-current motors with shafts direct coupled on to an extension of the roll shaft; three motors being chosen instead of one, in order to limit any fly-wheel effect at this point. The motor control is secured on the Ward Leonard system. Apart from the descriptive matter the gist of the whole paper and best illustration of what the system permits is provided by a series of diagrams giving the speed voltage and current diagrams of the rolling mill motors, and the reflected load upon the generating station during the rolling of an 18-inch girder from a 2-ton ingot, which indicate that the momentary current impulses frequently reached 7,000 amps.; the energy taken from the converter has a "peak" value of 4,500 kw., while the momentary fluctuations in the reflected load on the central station only amount to 200 and 250 kw., the load gradually rising from 400 to 900 kw.

Now that the electric reversing wheel problem has been solved it is possible to electrify rolling mills throughout. The cost of electric power is, of course, an important item, but in the case of mills with blast furnaces adjacent this cost will be found to be very low, "and should in no case exceed 0.5 per cent per kw-hour, while in certain cases, with modern plant and under favorable conditions, the cost of production has been brought down considerably below this figure." It is then possible in a rolling mill to entirely dispense with all coal-fired boilers and their attendant charges for firemen, conveyance of coal, removal of ashes, repairs and insurance costs. The electric power for operating the complete rolling mill, plant and accessories being primarily derived from the waste gases of the blast furnaces by means of gas-engine-driven electric generators.

Further advantages of the electrification of a rolling mill are summed up by the author as follows:

Increased output, the rolling mill motors being made to run at any desired speed direct coupled to the rolls. The speed of rolling being controlled only by considerations such as the rapid handling of the material and the mechanical strength of rolls and housings.

Extreme simplicity of the direct-coupled electric reversing mill, the whole operation of rolling, reversing and speed regulation being controlled by one lever.

Decreased cost of up-keep, as owing to the use of electric motors with their continuous rotary action and regular torque, the breakages of coupling boxes, standards, pinions and necks are reduced to a minimum.

Absolute control over rolling mill costs and power absorbed at any stage of all rolling operations, by the use of electric recording and automatic instruments, such exact control having been impossible in the case of steam.

Gain in space formerly occupied by ranges of boilers, coal bunkers, railway sidings, etc., which in some over-crowded works, or where land is high value, is an item of considerable importance.

The great reduction in power used in connection with reversing rolling mills, owing to the method of utilizing a balancing converter upon the Ilgner principle, the energy absorbed by the converter, which is derived direct from the central generating station or mains, being about one-tenth of the maximum value or torque upon the mill, even when the load fluctuates on the mill between 0 and 10,000 hp.

In the event of new mills being laid down, the ease with which the rolling mill motors can be applied direct to the rolls without the necessity of large and costly foundations, as in the case at present with heavy reciprocating steam rolling mill engines.

The very large reduction in the majority of cases of the power cost per ton of steel rolled, owing to the foregoing considerations. Less than 20 kw-hours are used per ton of blooms rolled, which in the case of mills having blast furnaces adjacent, or waste gases available, and producing electricity at 0.50 cents per kw-hour, works out at under 10 cents a ton.

Manufacture of Steel from High-Silicon Phosphoric Pig Iron by the Basic Bessemer Process, by A. Windsor Richards. In working the process some iron oxide is put into the basic converter, preferably an iron ore not too refractory, with or without a small quantity of lime, and on to this poured molten gray Cleveland iron, always low in sulphur, with silicon which may vary from 1.5 to 3 per cent. The metal is blown until all the silicon is oxidized, and the blowing continued until the appearance of the carbon flame; it is then interrupted by turning down the converter, and as much as possible of the perfectly fluid silicious slag is poured off. This slag contains 3 per cent of iron, 35 to 45 per cent silica and no phosphorus. It does not affect the linings to any appreciable extent owing to the low temperature during the first blowing, for while there is a little more corrosion on the sides of the converter a much better life is got from the bottoms, the net result being that the same quantity of dolomite per ton of steel is used now as when using basic iron. The final slag contains 8 to 11 per cent of iron, 14 to 20 per cent of phosphoric acid (95 to 100 per cent soluble in a 1 per cent solution of citric acid in water), and 11 to 12 per cent silica. Practically the whole of the iron in the oxide added for the desiliconizing is reduced and passes into the bath of metal, thus improving the yield.

The advantages of the process are thus summarized by the author: 1. An improved quality of steel, the phosphorus being under better control. 2. A high carbon steel for rails can be produced with the greatest regularity. 3. The utilization of native ironstone without foreign additions. 4. Reduced loss on blowing in consequence of less iron being ejected from the converter, less oxidation and direct reduction of a portion of the oxide of iron additions. 5. Cleanliness of working, involving less labor. 6. Rich fertilizing slag from pig iron containing 1.50 per cent or less of phosphorus.

The steel produced by this process rolls splendidly, and answers all that is required of it under the most rigid specifications, and the results obtained have effectually disposed of the theory, so long held by many, that 1 to 2 per cent of manganese, which is not only costly to add, but has to be got rid of again at great cost, is a necessary constituent of basic Bessemer iron.

Production of High-Class Steel from Pig Iron Containing Chromium, Nickel and Cobalt, by A. Windsor Richards. The paper describes a method by which a steel is produced containing approximately 1.5 per cent of nickel, with 0.25 per cent of cobalt and 0.30 per cent of chromium, from a pig iron containing 1.75 per cent of nickel and cobalt, 4 per cent of chromium and 4 per cent of silicon. Dr. Otto Massenez conceived the idea that if the iron were worked in a basic or neutral-lined, open-hearth furnace provided with slag notches the chromium might be removed by forming successive voluminous quantities of oxidizing slags, and as the chromic oxide was formed, removing these slags through the slag notches

before they become too thick. The process based on Dr. Massenez's idea was worked out at the Cleveland works by the author, and after many disappointments was finally successful, with the result that the greater part of the chromium was eliminated, but all the nickel and cobalt was retained in the steel.

Before adopting the open-hearth furnace experiments were first made in an acid Bessemer converter to determine whether chromium could be removed therein, but it was found that when only 0.4 per cent was present in the metal it was impossible to convert it owing to the extremely thick slag produced by the chromic oxide. Fluorspar was added, but this formed foamy slag and caused waste by blowing out. No better success was found by blowing the iron in a basic Bessemer converter.

The process of working consists in pouring the molten pig into an open-hearth furnace that has been charged with lime, basic slag and hematite iron ore. A thick foaming slag removed at the end of an hour carried with it part of the chromium. This operation is repeated four times for pig containing 4 per cent of chromium, after which the metal is treated like a normal open-hearth charge. The steel produced has a much higher yield point than that of normal carbon steels of similar carbon content, and possesses exceeding toughness. Tram rails tested to destruction after withstanding repeated blows alternately on the head and foot of each rail, by a 1-ton ball falling 25 feet, had pieces of the flange torn out, and at another blow split in the web, after which it took one more blow at 25 feet to effect complete fracture. Its resistance to reversal of strain is very marked. In all cases the steel has shown great improvement by being reheated, after finishing, to a temperature of 650° C. and cooling in air. In this heat treatment it is not soaked, but as soon as it attains 650° C. evenly throughout the mass, it is removed from the furnace.

An Investigation on the Use of Steam in Gas Producer Practice, by Prof. W. A. Bone and R. V. Wheeler. This lengthy paper of upwards of 31 pages represents a first instalment only of the account of a research carried out by the authors. The investigation comprised a series of five trials with a Mond gas-producer plant at a British iron and steel works. Each of the five trials extended over a full working week, with a plant supplying gas both for gas engines, for reheating and puddling furnaces all working under normal conditions. The only difference between the conditions from week to week was in the relative proportions of steam and air used in the blast for the producers which were varied by raising the steam saturation temperature of the blast in five equal stages from 60° to 80° C. Their enumeration of the general conclusions occupies some 4½ pages, from which the following chief features may be noticed:

(1) Quality and composition of the gas. The quality of the gas obtained, though always good, steadily deteriorated as the steam saturation temperature was raised beyond 65°. Thus, whereas, at 60° and 65° the average percentage of total combustibles in the gas exceeded what must be considered the high figure 47 per cent. it steadily dropped to about 42 per cent as the steam saturation temperature was raised to 80°. This fall off in quality was, it is true, partly counterbalanced by an increase in the quantity produced per ton of coal gasified; but the general efficiency of the process fell off as more steam was used. Further, the advantages gained by working at the lower steam saturation temperatures become more marked when the composition of the gas is taken into account. As the steam saturation temperature was raised the gas became richer in hydrogen and carbon dioxide, but much poorer in carbon monoxide, and the gain in hydrogen was more than counterbalanced by the loss in carbonic oxide.

(2) Thermal efficiencies of the plant. If the thermal efficiencies of the plant be considered it will be found that the use of steam beyond that required to saturate the air blast at 60° was not attended by any increased economy of working, but rather the reverse. Under the conditions of the trial, therefore, the thermal efficiency of the plant fell from 71.5 to 60.4 per cent as the steam saturation temperature was raised from 60° to 80°. Hence the use of steam over and above that required to saturate the blast at 60° does not lead to higher thermal efficiencies. In the author's opinion the maximum of advantage derivable from the use of steam depends to some extent on the thickness of the fuel bed, but under such working conditions as were maintained in the trials this maximum is probably attained with a steam saturation temperature between 60° and 65°, taking all the factors into consideration.

(3) Yields of ammonia. If a gas producer be regarded primarily as an apparatus for ammonia recovery, then undoubtedly it should be worked with the highest steam saturation temperature consistent with the production of combustible gas. Probably the best steam saturation temperature, if ammonia recovery be considered in conjunction with the suitability of the gas for furnace purposes and the thermal efficiency of the process, is somewhere in the neighborhood of 65°, or possibly between 65° and 70°. At 65° over 30 per cent of the nitrogen in the coal can be recovered as ammonia, or nearly double the amount usually recovered in by-product coking processes in conjunction with a very suitable gas for furnace purposes.

Relation Between the Process of Manufcture and Some of the Physical Properties of Steel, by F. W. Harbord. For many years it has been known to all steel manufacturers and metallurgists that steels made by different processes, although practically of the same composition, varied in their tensile strength, hardness and other physical properties, and it has been generally admitted that basic Bessemer steel was softer than acid Bessemer, and basic Siemens softer than acid Siemens. The author, therefore, presented a paper giving the result of numerous analytical and experimental investigations, from which are set out that in order to obtain the same physical properties each particular process requires its own special proportion of carbon.

Thus, from 30-ton steel upwards about 0.10 per cent more carbon is required in a basic open-hearth steel than in an acid Bessemer steel to give the same result, and if engineers require material of the same strength made from the basic open-hearth furnace as they have been accustomed to receive from the acid Bessemer, they must permit the manufacturer to increase his carbon approximately to this extent. The same applies in a much less degree to steel from the acid open-hearth and the basic open-hearth, but the essential point is that a reasonable increase in carbon must be permitted in order to obtain the same results. That this can safely be done is shown by practical experience, and also by the fact that the necessary elongation and reduction of area to satisfy all reasonable specifications can be obtained with this increase of carbon.

An examination of the results obtained, however, with the experimental bars shows that a basic open-hearth steel containing 0.50 per cent of carbon has the same hardness as an acid Bessemer steel containing 0.40 per cent of carbon, and that, approximately, for carbons above 0.35 per cent it is necessary that the carbon should be at least 0.10 per cent higher in basic open-hearth steel than in acid Bessemer steel to obtain the same hardness.

Further, on comparing acid Bessemer rails with basic open-hearth and basic Bessemer rails tested at several works under similar conditions the results generally confirm those given. A large number of deflection tests under the drop test in the author's possession also show that the difference in deflection between acid Bessemer, basic acid and especially basic Siemens is very marked, and although, owing to variations in section, etc., it has not been possible to compare and express these results in exact figures, they all confirm those obtained on the experimental bars. If, therefore, engineers wish to obtain rails of equal hardness from the basic open-hearth that they have been accustomed to from acid Bessemer steel, they must permit the manufacturer to increase the percentage of carbon to

give the required hardness, as otherwise, although the rails may satisfactorily pass all the usual tests required by the specification, there will soon arise under the conditions of heavy-load trains now customary serious trouble, due to spreading heads and undue wear.

American engineers, in their standard specifications, have already recognized the importance of this, and they vary their rail specifications according to the process of manufacture. Thus for acid Bessemer, 80-pound, 90-pound, 100-pound rails respectively, the percentage of carbon is 0.45 per cent to 0.55 per cent, 0.48 per cent to 0.58 per cent, and 0.50 per cent to 0.60 per cent, and for basic open-hearth, 0.50 per cent to 0.60 per cent, 0.55 per cent to 0.65 per cent. and 0.58 per cent to 0.68 per cent for similar rails. This permits an increase of about 0.08 per cent of carbon for the basic open-hearth rails, but in the author's opinion it will be quite safe to allow from 0.10 per cent to 0.12 per cent increase. He thinks it quite possible that experience may show that even more than this is permissible.

The Ageing of Mild Steel, by C. E. Stromeyer. The author, whose experience in regard to steam boilers is wholly exceptional, is firmly of the opinion that some grades of steel do deteriorate with extreme suddenness, and recites in his 55-page paper numerous surprising cases. He suggests, possibly, but this has not been established, brittleness has to be initiated either by the introduction of a crystal or by application of a stress, like the application of a shearing stress to the edges of the steel plates. Related phenomena are crystallization of supersaturated solutions of salts, notably sulphate of soda. The solution is a perfectly homogeneous one, but on introducing a crystal, and thereby relieving or initiating a strain in the fluid, sudden segregation of part of the salt takes place. The well-known sudden solidification of molten phosphorus is a similar phenomenon. The slow changes which take place in solutions of carbonate of soda are analogous to some eutectic phenomena in solid metals. and may help to an understanding of this difficult subject of ageing. At 10° C., 100 grams of water will dissolve 37 grams of sodium carbonate, provided it is associated with seven equivalents of water, and has crystalized in rhombohedric form. Another salt, also containing seven equivalents of water, but of rhombic form, will, at 10° C., only dissolve at the rate of 26.3: 100 of water. A distinct ageing effect can here be noticed, for apparently the former of these salts, although dissolved, slowly changes into the latter form; and if there is more than 26.3 per cent present slow precipitation of the surplus salt takes place. The seven-equivalent rhombic salt while in solution can also associate itself with another 3 per cent of water, whereby it converts itself into a salt of which at 10° C. only 12.6 parts can be dissolved by 100 of water. Thus, slowly and without apparent cause soda segregates or crystallizes out of a solution which was certainly not supersaturated. Here we have a case in which time alone produce changes in the constituents of a fluid, which, if it were a solid, would become evident under the microscope as changes of structure.

Omitting the author's numerous tables, he points out that certain steels do possess ageing qualities, that some steels tend to improve with time others to deteriorate. That as yet the process which gives results which are most in harmony with practical experience is to plane the edges of two samples, to nick them with a specially prepared chisel, and then to bend one sample at once and the other after waiting some weeks or after boiling.

But despite the number of failures which he attributes to ageing, the author disclaims any desire to pose as a scaremonger. He says, "Although I am responsible for the safety of over 8,000 boilers I do not feel alarmed by the knowledge I have gained that steel and iron have ageing tendencies; for cases are brought to my notice every year in which structures have been loaded far beyond the customary limits and yet have shown no signs of giving way. These are experiences which it is difficult to explain, except on the supposition that some materials improve with age; but they naturally raise the question as to whether one cannot perceive that all materials should be of this nature, in which case many customary high factors of safety might be considerably reduced. The value, in my opinion, of the results obtained in these experiments is that they direct attention to a subject which, if followed up, may lead to an improvement of the ageing properties of steel."

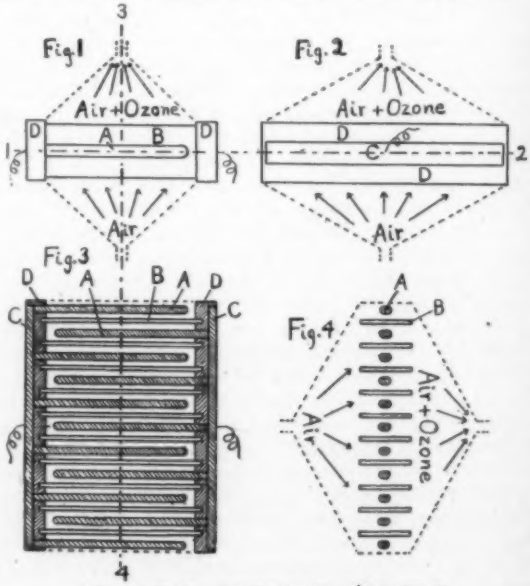
Induced Draught With Hot Air Economizers for Steel Works and Blast Furnace Boilers, by A. J. Capron. This paper describes some tests carried out with the Ellis and Eaves hot-air induced draught system at various works. Directly the paper has no distinct metallurgical interest. The tests given lack many essential details, and the paper would have been severely handled had it been read, say, at the Institution of Mechanical Engineers. But it is dubious as to whether the Council of that institution would have accepted it.

Abstracts of the balance of papers will be published in our next issue.

Test of an Ozonizer.

By Arthur W. Ewell.

A statement of the efficiency of an ozonizer should give the amount of ozone produced by a given amount of electricity and also the amount of ozone produced by a given amount of electrical energy. Both should be stated for different ozone concentrations, since the efficiency varies greatly with the concentration. The first measure of the efficiency (grams per coulomb) can easily be obtained by measuring the number of grams of ozone produced per second or minute and the electric



FIGS. 1 TO 4.—CONSTRUCTION OF OZONIZER.

current flowing through the ozonizer. The second measure of the efficiency (grams per kilowatt-hour) requires in addition to the current the potential applied to the ozonizer and the power factor if an alternating current is employed. It is difficult to measure accurately the high difference of potential applied to an ozonizer (which possesses considerable capacity), and the determination of the power factor is much more difficult, although the writer has shown an approximate method of calculation.[1]

If an alternating current is employed—and the most efficient type of ozonizer,[2] the Siemens (dielectric), requires an alter-

[1] Am. Jo. of Science, Nov., 1906. Phys. Zeitschrift, No. 25, 1906.
[2] Warburg, Ann. der Physik, 20, 1906, p. 734. Ewell, Phys. Rev., April, 1906.

nating current—the electrical energy can be determined most satisfactorily by measuring the watts at the primary of the transformer which supplies the high potential current to the ozonizer and subtracting the transformer losses. The latter must be small if the method is to be accurate, and therefore the transformer should operate the ozonizer at about its own normal potential and capacity.

The writer has recently designed and had constructed an ozonizer of such dimensions that a standard General Electric transformer (No, 27,615, 13,200-110 volts, 200 watts) would operate it efficiently. This ozonizer embodied those features which, as the writer has shown,[2] give the highest efficiency and least danger of breakdown, namely, flat, narrow, bare, electrodes with glass midway between.

The construction is outlined in Figs. 1 to 4. Fig. 3 is a section along 1-2, and Fig. 4 along 3-4. The bare electrodes A narrow in the direction of the gas current, were separated by the glass plates B, which were mounted in the insulating supports D. The actual number of electrodes was 27. The dotted lines indicate walls to confine the air current.

Between the compression pump and the ozonizer the air traversed a Junker gas meter, potassium permangate solution to remove organic matter and calcium drying columns. The air and ozone escaped from the ozonizer through a large glass tube provided with glass stop-cocks at the ends, by closing which a sample of the ozone mixture could be secured. The

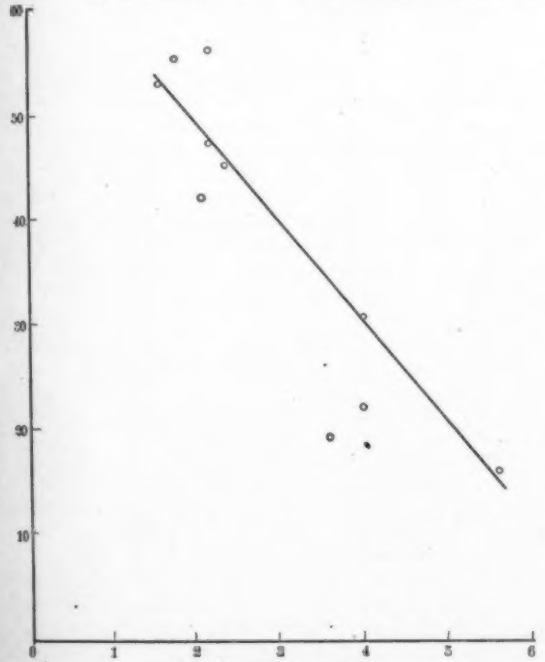


FIG. 5.—YIELD CURVE.

Horizontal axis = concentration (grams of ozone per cubic meter). Vertical axis = yield (grams of ozone per kilowatt-hour). (The points below the line are for excessive currents.)

content of ozone in such a sample was determined by absorption in potassium iodide solution, acidifying and titration with sodium thiosulphite. The current flowing through the ozonizer was determined by measuring with a Kelvin electrostatic voltmeter the fall of potential across a known, non-inductive resistance. On the primary side of the transformer the potential was determined with a similar instrument, the current with a Hoyt ammeter and the watts with a Thomson wattmeter.

The experimental readings and the calculated results of the tests are given in the following table:

[2] Ewell, Phys. Rev., Feb., 1906, p. 111; April, 1906, p. 232. Reviewed in this journal, vol. 4, No. 3, p. 108. Journal of the Worcester Polytechnic Institute, Jan., 1907, p. 98.

Primary Watts.	Transformer Losses.	Current Through Ozonizer (Milliamperes).	Gas Velocity (Litres per Minute).	Milligrams Ozone per Minute.	Concentration (Grams Ozone per Cubic Meter).	Yield (Grams Ozone per Coulomb).	Yield (Grams Ozone per Kilowatthour.
113	43	9.3	24	41	2.1	.088	42
111	43	10.5	6	22	3.6	.035	19
107	40	9.1	24	52	2.2	.096	47
105	40	8.6	6	24	4.0	.047	22
105	40	8.6	3	17	5.6	.033	16
97	40	8.3	24	53	2.2	.107	56
84	36	6.8	24	44	1.8	.107	55
78	32	6.5	6	24	4.0	.061	31
75	31	5.7	24	39	1.6	.115	53
44	24	2.7	6	15	2.4	.093	45

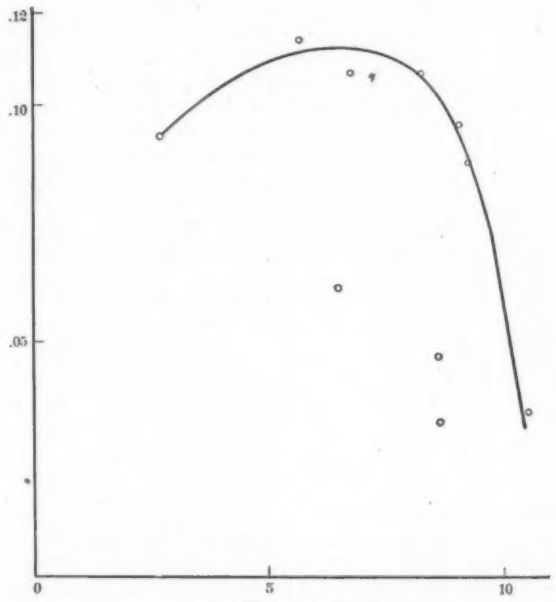


FIG. 6.—YIELD CURVE.

Horizontal axis = current through ozonizer (milliamperes), vertical axis = yield (grams of ozone per coulomb). (The points below the line are for high concentrations.)

The copper loss of the transformer never exceeded 1 watt, and therefore the losses in the table are (within 1 watt) the iron losses determined by the watts consumed when the secondary circuit was open. The yields are represented graphically in Figs. 5 and 6. From the above table it will be seen that the points below the line are: in Fig. 5 for excessive currents and in Fig. 6 for high concentration. The decrease in yield in both cases is owing to the deozonizing effect of the current. A comparison of the above yields per kilowatt-hour, *for the different concentrations,* with the published tests of other ozonizers, will show the superiority of this design.

This ozonizer was designed for the Galpin Laboratories, Fifty-seventh Street and Sixth Avenue, New York City.

WORCESTER POLYTECHNIC INSTITUTE, May, 1907.

Electrometallurgy.—In a paper presented before the recent Engineering Conference of the (Brit.) Institution of Civil Engineers, Mr. Bertram Blount remarked that "at the present there is more solid progress being made in electrometallurgy than at any previous time." As the principal electrometallurgical industries he sketches the refining of copper and the manufacture of aluminium and of sodium, but "the largest of all electrometallurgical industries will be the manufacture of steel." The Héroult and the Kjellin processes "represent two of the most distinctive and promising." "Zinc is a metal not at present smelted electrically, but which for chemical and physical reasons is excellently fitted for productions in that manner." There is much the same reason to replace the present retort furnaces by an electric furnace, as there was in the case of phosphorus and carbon bisulphide.

Metallurgical Calculations.

By J. W. Richards, Ph. D.

Professor of Metallurgy in Lehigh University.

Smelting of Copper Ores.

The smelting down to matte is done either in reverberatory furnaces or in shaft furnaces. The charges are usually composed of roasted ore, roasted matte or speiss, mixed with unroasted sulphides, usually concentrates, and with siliceous rock or limestone as flux. The important reaction during the smelting down is the formation of Cu^2S by the copper present, the formation of other sulphides, mostly FeS, by the larger part of the sulphur left over, and the slagging of the elements which do not enter the matte. If much lead is present metallic lead will separate out, carrying the bulk of the precious metals, but this phenomenon will be considered under the metallurgy of lead. The important subjects for calculation are: the proportions of roasted and unroasted materials to be used, and the proportions of flux to use to make a satisfactory slag.

Some data of importance for calculations on copper smelting have been determined in the author's laboratory by Mr. Walter S. Landis.

A copper matte containing 47.3 copper, 26.2 iron and 23.6 sulphur, was found to have the following thermo-physical characteristics:

Melting point		1,000° C.
Mean specific heat, $0 - t = Sm$	$= 0.21104 - 0.0000366\,t$	
Actual specific heat, at $t = S$	$= 0.21104 - 0.0000732\,t$	
Heat content, solid, at 1,000°	=	174 Cal.
Heat content, liquid, at 1,000°	=	204 "
Latent heat of fusion, at 1,000°	=	30 "
Specific heat, at 1,000°	=	0.138

Heat of formation from Cu^2S and FeS not satisfactorily determined.

A copper blast furnace slag containing 35.5 SiO^2, 39.7 FeO, 1.0 MnO, 11.4 CaO, 2.7 MgO, 9.2 Al^2O^3, 0.42 Cu, 0.42 S, was found to have the following characteristics:

Melting point		1,114° C.
Mean specific heat, $0 - t = Sm$	$= 0.20185 + 0.0000302\,t$	
Actual specific heat, at $t = S$	$= 0.20185 + 0.0000604\,t$	
Heat content, solid, at 1,114°	=	262 Cal.
Heat content, liquid, at 1.114°	=	302 "
Latent heat of fusion, at 1,114°	=	40 "
Specific heat, at 1,114°	=	0.269

Heat of formation from its constituent oxides = 133 Calories per kg. of slag.

In the case of the slag, its melting point and latent heat of fusion are not nearly as sharply defined as those of the matte, since the matte melts sharply, but the slag goes through a pasty or viscous stage. The values given are the best approximations which could be gotten from the experiments. As regards heat of formation, the constituent oxides were carefully weighed, mixed with a known weight of carbon, and ignited in a Berthelot bomb calorimeter. Several experiments gave satisfactory concordant results, so that the heat of combination of the constituents of this slag may be taken as not far from 133 Calories per kilo. of slag. By following this scheme it is possible to measure experimentally the heat of formation of any slag whose analysis is known.

Reverberatory Smelting.

In the reverberatory furnace the atmosphere is in no case strongly reducing; it may be varied from weakly reducing to strongly oxidizing, and in the smelting operation usually averages about neutral. The consequence of this is that copper oxides or sulphate in the charge are not deoxidized by carbon, as in the shaft furnace, nor is Fe^2O^3 reduced to FeO by carbon, but the oxygen thus contained in the charge largely goes off with sulphur as SO^2, thus decreasing the amount of sulphur left to form matte, and therefore increasing the percentage of copper in the matte formed. The reactions are mainly:

$$2CuO + 2FeS + 2Fe^2O^3 + 6SiO^2 = SO^2 + Cu^2S + 6FeSiO^3.$$

The slag $FeSiO^3$ is, however, heavy and viscous; it would contain 45 per cent of silica, but runs better and gives a cleaner separation from matte if some lime is added to it. The replacement of 10 per cent of FeO in this silicate by 10 per cent of CaO lowers its melting point from 1,110° C. to 1,010°, and therefore makes a slag that is much easier to keep fluid and of greater fluidity at any given furnace temperature.

Problem 105.

Peter's (*Modern Copper Smelting*, p. 446) gives the composition of the average mixture smelted in the reverberatory furnaces at Argo, Col., as

	Per Cent.
SiO^2	33.9
Iron	10.8
$BaSO^4$	15.5
Al^2O^3	5.6
$CaCO^3$	8.5
$MgCO^3$	5.8
ZnO	6.1
Copper	2.0
Sulphur	5.1
Oxygen	6.4
	99.7

The furnace smelts 50 tons of this mixture (charged hot, at 350° C.) in 24 hours, using 13.5 tons of bituminous coal and producing a matte with 40 per cent of copper. Outside dimensions of furnace 20 x 40 x 6 feet. Area of stack, fire-box and hearth 16, 32.5 and 481 square feet, respectively. Temperature of stack gases 1,000° C. Composition of the coal: moisture 1.40 per cent, fixed carbon 54.90, volatile matter 32.90, ash 10.80 per cent; assume 10 per cent more air used than necessary for theoretical combustion. Temperature of slag and matte 1,200°.

Required:

(1) The weight of matte produced, assuming the slag to carry 0.2 per cent of copper (as intermingled matte), and the matte 40 per cent.

(2) The loss of copper in the slag, expressed in per cent of the total copper present.

(3) The percentage of the calorific power of the fuel existing in the stack gases, the slag and the matte.

(4) The heat lost by radiation and conduction in pound Calories per minute per square foot of furnace surface.

(5) The velocity of the hot gases at the base of the stack.

(6) The horse-power theoretically obtainable by passing the hot gases through a boiler which reduces their temperature to 200° C., and which, together with the steam engine gives a total thermomechanical efficiency of 7.5 per cent upon the heat furnished to (entering) the boiler.

Solution:

(1) The entire matte formed, that free plus that intermingled with the slag, will be per 100 of ore mixture

$$2.0 \div 0.40 = 5.0 \text{ pounds.}$$

	Pounds.
FeS in this matte $= 5.0 - 2.5$	$= 2.5$
Fe in this matte $= 2.5 \times 56/88$	$= 1.6$
Fe going to slag as FeO $= 10.8 - 1.6$	$= 9.2$
FeO in slag $= 9.2 \times 72/56$	$= 11.8$
Constituents of slag:	
SiO^2	$= 33.9$
FeO	$= 11.8$
$BaO = 15.5 \times 153/233$	$= 5.9$
Al^2O^3	$= 5.6$
$CaO = 8.5 \times 56/100$	$= 4.8$

$MgO = 5.8 \times 40/84$	=	2.8
ZnO	=	6.1
Weight of slag	=	70.9
Copper in slag as intermingled matte	=	0.14
Intermingled matte lost in slag	=	0.35
Free matte obtained = 5.0 — 0.35	=	**4.65** (1)

(2) $$\frac{0.14}{2.00} = 0.07 = 7 \text{ per cent.} \qquad (2)$$

(3) The calorific power of the fuel may be calculated from its proximate analysis by the method of Goutal (ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, April, 1907, p. 145), as follows:

Pure fuel 1.0000 — 0.1220	=	0.8780
Per cent of this volatile $\frac{0.3290}{0.8780}$	=	37.5 per cent.
Calorific power of volatile matter	=	8,650 Cal.
Calorific power (to liquid H^2O):		
Carbon 0.5490 × 8,100	=	4,447 "
Vol. matter 0.3290 × 8,650	=	2,846 "
Sum	=	7,293 "
Water formed = 0.45		
Latent heat of vaporization of water = 0.45 × 606.5	=	273 "
Metallurgical calorific power	=	7,020 "

Assuming the volatile matter to be 15 per cent hydrogen, 40 per cent oxygen and 45 per cent carbon, the coal contains:

Hydrogen 0.329 × 0.15	= 0.049
Volatile carbon 0.329 × 0.45	= 0.148
Fixed carbon	= 0.549
Total carbon	= 0.697

and the air necessary for combustion and products therefrom are per unit weight of fuel used:

Oxygen for C = 0.697 × 8/3	=	1.859 pounds.
Oxygen for H = 0.049 × 8	=	0.392 "
Sum	=	2.251 "
Oxygen in coal = 0.329 × 0.40	=	0.132 "
Oxygen needed from air	=	2.119 "
Air needed $= \frac{2.119 \times 13/3 \times 16}{1.293}$	=	113.7 ft³.
Nitrogen therein = 113.7 × 0.792	=	90.0 "
10 per cent surplus air	=	11.4 "
Volume of $CO^2 = \frac{2.556 \times 16}{1.98}$	=	20.7 "
Volume of $H^2O = \frac{0.455 \times 16}{0.81}$	=	9.0 "

Assuming the tons mentioned are of 2,000 pounds each, the heat generated per 27,000 pounds of fuel used per day is

$$27{,}000 \times 7{,}020 = 189{,}540{,}000 \text{ pound Calories,}$$

and, therefore, per 100 pounds of ore smelted:

$$189{,}540{,}000 \div 1{,}000 = 189{,}540 \text{ pound Calories.}$$

The fuel used per 100 pounds of ore being 54 pounds, the products of combustion are 54 times the above calculated volumes, to which must be added

7.4 pounds $SO^2 = (7.4 \times 16) \div 2.88 = 41$ cubic feet.
6.0 pounds $SO^2 = (6.0 \times 16) \div 3.60 = 27$ " "
6.7 pounds $SO^2 = (6.7 \times 16) \div 1.98 = 54$ " "

found later to be driven off the charge. The stack gases and the heat carried out by them are as follows:

CO^2	613 × 0.59 × 1,000 =	361,670	ounce Cal.
H^2O	243 × 0.49 × 1,000 =	119,070	" "
N^2 Air	2,738 × 0.33 × 1,000 =	903,540	" "
SO^2	41 × 0.66 × 1,000 =	27,060	" "
SO^2	27 × 0.58 × 1,000 =	15,660	" "
		1,427,000	" "
	=	89,200	pound Cal.

Proportion of the calorific power of the fuel in the hot gases:

$$\frac{89{,}200}{189{,}540} = 0.47 = 47 \text{ per cent.} \qquad (3)$$

To find the heat in the slag tapped, taking Landis's determination of 302 Calories in slag melted at its melting point, 1,114°, and assuming a specific heat in the melted state of 0.27, we have the heat in it per unit weight at 1,200°:

$$302 + (0.27 \times 86) = 325 \text{ Cal.}$$

Heat in total slag:

$$325 \times 70.9 = 23{,}045 \text{ Cal.}$$

Proportion of calorific power of fuel in hot slag:

$$\frac{23.045}{189{,}540} = 0.121 = 12.1 \text{ per cent.} \qquad (3)$$

To find the heat in the matte, we may take Landis's determination of 204 Calories in matte just melted at 1,000°, and assuming a specific heat of 0.14 we have heat in unit weight at 1,200°:

$$204 + (0.14 \times 200) = 232 \text{ Cal.}$$

And, therefore, heat in the matte formed:

$$4.65 \times 232 = 1{,}080 \text{ Cal.}$$

Proportion of calorific power of fuel in melted matte:

$$\frac{1{,}080}{189.540} = 0.006 = 0.6 \text{ per cent.} \qquad (3)$$

(4) The heat lost by radiation and conduction equals all the heat brought in and generated by combustion and other chemical reactions in the furnace, minus that absorbed by chemical reactions in the furnace, and minus that issuing as sensible heat in the stack gases, slag and matte. The ore mixture being charged hot, at 350° C., and having an assumed specific heat of 0.15, its sensible heat is

	Calories.
100 × 0.15 × 350 =	5,250
Add heat of combustion of coal =	189,540
Heat available =	194,790

The heats of chemical reaction of sulphates and oxides on sulphides are quite complex, and we will show the calculation in detail at the end of the problem. Suffice here to give the end results of the calculation:

	Calories.
Chemical reactions, net *absorption*	16,480
Heat of formation of slag, *evolved*	+ 9,430
Net heat *absorbed* in reactions and combinations	7,050

The heat balance sheet will therefore show:

Available.

	Calories.
Heat in hot charges	5,250
Heat of combustion of coal	189,540
	194,790

Distribution.

In chimney gases	89,200
In liquid slag, tapped out	23,045

In liquid matte, tapped out.....	1,080
Absorbed in reactions and combinations	7,050
Loss by radiation and conduction.....	74,425
	194,790

The loss by radiation and conduction per day will be:

	Calories.
$74,425 \times 270$	$= 20,093,000$
per minute $20,093,000 \div 1,440$	$= 14,000$

The whole outside area of the furnace, including the base, is

$$2(20 \times 40) + 2(6 \times 40) + 2(6 \times 20) = 2,320 \text{ sq. ft.}$$

Loss in pound Calories per square foot of surface per minute:

$$14,000 \div 2,320 = \mathbf{6.0} \text{ pound Cal.}$$

(5) The volume of stack gases, at 0° C., has been found to be 3,662 cubic feet per 100 pounds of fuel used, or $3,662 \times 270 = 988,740$ cubic feet per day = 11.4 cubic feet per second. At 1,000° this volume would be

$$11.4 \times (1,000 + 273) \div 273 = 53.2 \text{ cubic feet.}$$

And since the area of stack cross-section is 16 square feet the velocity of the hot gases entering the stack is

$$53.2 \div 16 = \mathbf{3.3} \text{ feet per second.} \qquad (5)$$

This is a low velocity, and shows good design, which will result in better economy of fuel than if high velocity were used.

(6) The gases were found to contain 89,200 pound Cal. per 100 of ore smelted, or per day:

$$89,200 \times 1,000 = 89,200,000 \text{ pound Cal.}$$

per hour $= 3,717,000$ " "

Since 1 hp. equals 1,400 pound Cal. per hour, we have:

Horse-power at 100 per cent efficiency:

$$3,717,000 \div 1,400 = 2,650$$

Horse-power at 7.5 per cent efficiency:

$$2,650 \times 0.075 = \mathbf{199} \text{ H. P.} \qquad (6)$$

In connection with requirement (3) of above problem it will be interesting and instructive to discuss the chemical and especially the thermochemical phenomena accompanying the smelting down of the ore mixture. The discussion will be clearest if we take the actual figures of the problem in question.

Aside from the SiO^2, Al^2O^3, etc., the ore mixture contains

	Per Cent.
Fe	10.8
Cu	2.0
S	5.1
O	6.4

And these four ingredients are present either as FeS, FeO, Fe^2O^3, $FeSO^4$, Cu^2S, Cu^2O, CuO or $CuSO^4$. With the above quantities of the four elements in question, however, the manner in which they are combined is fixed within rather narrow limits. Each of the four binds each of the others, and it can be found, by some patience and trying out, that the four elements, constituting 23.4 per cent of the ore mixture, must be combined about as follows in order to be present in the quantities given:

	Per Cent.
CuO	1.0
$CuSO^4$	3.0
FeS	7.3
$FeSO^4$	8.9
FeO	0.4
Fe^2O^3	3.7

The best proof of this statement is to resolve the weights of these compounds into their components, and to thus prove that they agree with the premises.

On melting this down to 40 per cent matte we produce

Cu^2S	2.5 per cent in matte.
FeS	2.5 per cent in matte.
SO^2	7.4 per cent in gases.
FeO	11.8 per cent to slag.

The heat represented by the formation of the products must be subtracted from the heat of formation of the materials reacting to get the net heat of the reaction. We will multiply the amount of each material by the heat of formation of unit weight from its elements as follows:

		Cal.
CuO	$1.0 \times (37,700 \div 79.6) = 1.0 \times 473 =$	473
$CuSO^4$	$3.0 \times (181,700 \div 159.6) = 3.0 \times 1,139 =$	3,417
FeS	$7.3 \times (24,000 \div 88) = 7.3 \times 273 =$	1,993
$FeSO^4$	$8.9 \times (214,500 \div 152) = 8.9 \times 1,411 =$	12,558
FeO	$0.4 \times (65,700 \div 72) = 0.4 \times 913 =$	365
Fe^2O^3	$3.7 \times (195,600 \div 160) = 3.7 \times 1,223 =$	4,525
	Sum =	23,331

Heat of formation of products:

Cu^2S	$2.5 \times (20,300 \div 159) = 2.5 \times 128 =$	320
FeS	$2.5 \times (24,000 \div 88) = 2.5 \times 273 =$	683
SO^2	$7.4 \times (69,260 \div 64) = 7.4 \times 1,082 =$	8,007
FeO	$11.8 \times (65,700 \div 72) = 11.8 \times 913 =$	10,773
	Sum =	19,782
	Difference, heat absorbed =	3,549

We have, therefore, a deficit, or heat to be supplied. This deficit is increased by the heat required to decompose $BaSO^4$ into BaO and SO^2, $CaCO^2$ into CaO and CO^2 and $MgCO^3$ into MgO and SO^2; while it is decreased by the heat of combination of Cu^2S and FeS to form matte, and the heat of combination of SiO^2 with BaO, Al^2O^3, CaO, MgO, ZnO and FeO to form slag.

The driving off of SO^2 and CO^2 absorbs

	Calories.
SO^2 from BaO, SO^2 $6.0 \times 1,189 =$	7,134
CO^2 from CaO, CO^2 $3.7 \times 1,026 =$	3,796
CO^2 from MgO, CO^2 $3.0 \times 666 =$	1,998
Sum =	12,928

The net result of all these reactions, leaving out the formation heat of the slag from its oxide constituents, is

	Lb. Cal.
Absorbed $23.331 + 12,928 =$	36,260
Evolved	19,780
Deficit	16,480

And even if we credit the heat of formation of the slag:

	Lb. Cal.
70.9×133	$= 9,430$
there remains a net deficit of	7,050

The reaction of the ore mixture to form matte and slag is therefore an endothermic operation, in spite of the fact that much sulphur goes off as SO^2. The prime reason for this is that the bulk of the sulphur in the roasted ore was present as sulphate and not as sulphide.

Problem 106.

A copper blast furnace has at its disposal materials of the following compositions in percentages:

	Cu.	*Fe.*	*S.*	*SiO^2.*
Selected raw ore....	15	20	35	25
Roasted concentrates	25	35	10	12
Refinery slag.....	50	10	—	25
Limestone	CaO — 50			1

It is desired to make a matte with 50 per cent copper and a slag containing 35 per cent SiO^2, 40 per cent FeO and 15 per cent CaO, or with these ingredients in those proportions.

Required:

(1) The proportions of charge.

(2) A balance sheet showing distribution of these materials.

Solution: The foregoing conditions are those which frequently confront the copper smelter. He has at hand raw ore and roasted concentrates, whose relative quantities he can usually vary at will by simply concentrating and roasting more or less material. He has return slags from the refinery furnaces which, however, are not unlimited in quantity but bear a general relation to the weight of matte made and sent on to be further operations. Finally, the limestone can be varied at will. It will readily be seen that if the charge is fixed at a certain quantity of raw ore to start with, that there are then three variables, the quantities of the other three materials, and to fix these there are practically only two conditions to be fulfilled, the two ratios between three components of the slag. In order to make a practical solution, it is necessary to make an assumption which will practically reduce the number of variables by one, and on looking over the ground it is seen that the most rational assumption which can be made is to assume the refinery slag to bear a given relation to the weight of matte produced. Such an assumption eliminates the weight of refinery slag as a variable, and leaves us with only two variables and two conditions to fill, which makes a solution possible. Assuming the charges to be based on 100 of roasted ore, we can call the weight of roasted concentrate used X, the weight of refinery slag Y, and the weight of limestone Z, and then figure out the weight of matte produced in terms of X, Y and Z. Assuming then that the refinery slag is, say, 0.25 of the weight of matte, we have $Y = \frac{1}{4}$ (expression for weight of matte), and thus one equation between X Y and Z. The ingredients of the slag being figured out in terms of X, Y and Z, the assumed relations between FeO, CaO and SiO^2 in the slag give us two more equations between X, Y and Z, and thus all three quantities can be determined.

The provisional balance sheet, based on 100 of ore and X, Y and Z of other ingredients of the charge, will be as follows:

BALANCE SHEET.

Ore.	(100).	*Matte.*		*Slag.*		
Cu	15	Cu	15			
Fe	20	Fe	7.2 + 0.14Y	FeO	16.5 — 0.18Y	
S	35	S	7.8 + 0.03X + 0.26Y			
SiO^2	25			SiO^2	25.0	
R'st'd						
Conc.	(X).					
Cu	0.25X	Cu	0.25X			
Fe	0.35X	Fe	0.12X	FeO	0.30X	
S	0.10X	S	0.10X			
SiO^2	0.12X			SiO^2	0.12X	12
Ref.						
Slag.	(Y).					
Cu	0.50Y	Cu	0.50Y			
Fe	0.10Y	Fe	0.10Y			
SiO^2	0.25Y			SiO^2	0.25Y	
Lime-						
stone.	(Z).					
CaO	0.50Z			CaO	0.50Z	
SiO^2	0.01Z			SiO^2	0.01Z	

Notes on above balance sheet:

Copper in the matte	15 + 0.25 X + 0.50 Y
Weight of matte (50 per cent Cu)	30 + 0.50 X + 1.00 Y
Weight of S in matte	7.8 + 0.13 X + 0.26 Y
Weight of Fe in matte	7.2 + 0.12 X + 0.24 Y

These weights of S and Fe are therefore provided for under the column "matte," taking them from the various materials charged.

The refinery slag being assumed 0.25 of the matte, we have at once

$$Y = 0.25\ (30 + 0.50\,X + 1.00\,Y)$$
$$= 7.5 + 0.13\,X + 0.25\,Y$$

whence $Y = 10 + 0.17\,X$

That is, the refinery slag equals in weight 0.1 the ore plus 0.17 the roasted concentrates. This practically amounts to leaving the roasted concentrates and limestone as the only variables.

The problem can now be solved by summing up the ingredients of the slag as follows:

$$FeO = 16.5 - 0.18\,Y + 0.30\,X$$
$$SiO^2 = 25.0 + 0.25\,Y + 0.12\,X + 0.01\,Z$$
$$CaO = 0.5\,Z$$

or substituting $Y = 10 + 0.17\,X$

$$FeO = 14.7 + 0.27\,X$$
$$SiO^2 = 27.5 + 0.16\,X + 0.01\,Z$$
$$CaO = 0.5\,Z$$

And since the requirements of the slag are that

$$SiO^2 = \frac{35}{40}\,FeO$$

and

$$CaO = \frac{15}{40}\,FeO$$

we have:

$$27.5 + 0.16\,X + 0.01\,Z = \frac{35}{40}\,(14.7 + 0.27\,X)$$

$$0.50\,Z = \frac{15}{40}\,(14.7 + 0.27\,X)$$

whence

$$X = 195 \quad Z = 48$$

and therefore, $Y = 43$

The final balance sheet then becomes:

BALANCE SHEET.

Ore.	(100).	*Matte.*		*Slag.*	
Cu	15	Cu	15		
Fe	20	Fe	20		
S	35	S	35		
SiO^2	25			SiO^2	25
Rs'l'd Conc.	(195).				
Cu	49	Cu	49		
Fe	68	Fe	17	FeO	66
S	20	S	10		
SiO^2	23			SiO^2	23
Ref. Slag.	(43.)				
Cu	22	Cu	22		
Fe	4	Fe	4		
SiO^2	11			SiO^2	11
Limestone.	(48).				
CaO	24			CaO	24
SiO^2	1			SiO^2	1
			172		150

Matte.	*Per Cent.*	*Slag.*	*Ratio.*
Cu	86 = 50	SiO^2	60 = 36
Fe	41 = 24	FeO	66 = 40
S	45 = 26	CaO	24 = 14
	172		150 90

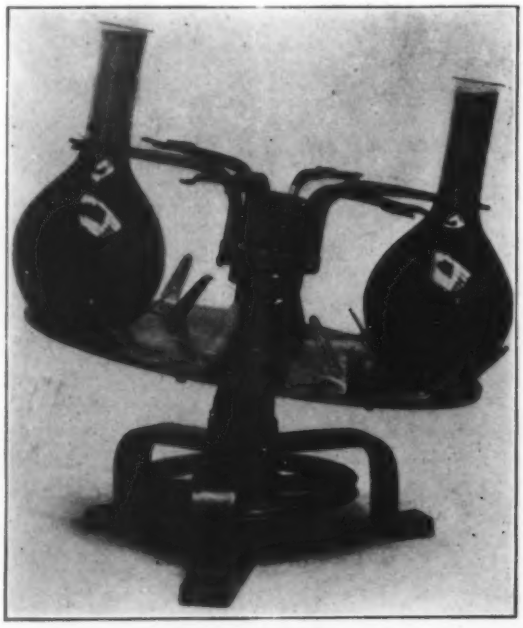
Furnace managers are usually afraid of X, Y and Z, and in regular running there is usually little need for an algebraic solution, yet many occasions arise when a judicious use of algebra solves a problem in an exact manner which hardly any amount of guessing or approximating can attain efficiently. In bringing forward this solution we may lay ourselves open to being called pedantic or academic, but the fact is that *the conditions of this problem* were proposed to the writer as a difficult nut to crack by a practical copper smelter, and the algebraic solution furnished was characterized by him as the most satisfactory solution of this class of problems which he had yet seen.

A New Shaking Device for the Chemical Laboratory.*

By J. M. Camp.

The alchemist of old failed in his search for the philosopher's stone, whose contact with the baser metals was to transmute them into the desired gold and silver. Nor has the later day chemist, for obvious reasons, found this magic pebble, but he has found the secret of changing the baser oxides into the equivalent of gold and silver. And when we compare the laboratories of the present day with those of the ancients, with their meagre supply of crude reagents, and whose apparatus included only forge-like furnaces and retorts, we cannot but marvel at their persistency in the face of such difficulties and the wonderful results they obtained.

In those days the laboratory was more like a forge shop. now it is approaching more and more to the mechanical, with its automatic samplers, grinders and stirring machines doing the manual labor, leaving the operator free for the more delicate



SHAKING DEVICE.

manipulations. And in the present day equipment to keep pace with the ever-increasing demands of the mills and furnaces, one is called upon to use every facility whereby quickness and accuracy may work together towards the accomplishment of the best results.

Among the various pieces of apparatus going to make up the equipment of the modern laboratory it is the purpose of this article to describe the latest appliance, in the shape of a shaking device. It was designed and is particularly adapted for the purpose of hastening the precipitation of phosphorus by the well known and almost exclusively used molybdic acid method, and in the solution of steels or pig irons for carbon combustion. But is equally useful where agitation is desired in a flask for either dissolving or precipitating. As can be seen from the photographs it consists of a frame supporting a vertical shaft, which is revolved by a 6-inch pulley wheel. The upper part of the shaft is bent slightly from the perpendicular. Encircling the bent portion of the shaft is a hub, which in turn supports a flat disc on which the flasks to be shaken are attached. The hub and disc are prevented from turning. when the shaft is revolved, by suitable teeth on the underside of the hub, meshing into corresponding teeth on the top of the supporting frame.

On revolving the shaft the motion of the disc is ideal for the purpose intended, and can be best likened to the simultaneous pitching and tossing of the deck of a ship in a tumultuous sea. With each revolution of the shaft a wave travels around the flask or flasks on the disc exactly as in hand shaking, and by increasing or diminishing the number of revolutions the number and intensity of the wave movement is controlled.

To obtain the maximum agitation and still retain the solutions in the flasks, without corking, from 100 to 140 r. p. m. has been found very satisfactory. The disc is made to hold six flasks, any one of which can be placed in or removed from the machine in a fraction of a second. The gripping device is movable, up or down, enabling it to be quickly adjusted to hold any size flask from a 6-ounce to a 24-ounce florence or erlenmeyer.

The electrical current required to operate it is 0.12 amp. at 250 volts, hence the power is 30 watts, or about the equivalent of the 1/25 hp.; *i. e.*, less than the average desk fan motor is consuming, so that with the proper countershaft to give the desired number of revolutions any source of power may be used.

Heat can be applied to the apparatus if desired by means of a circular burner, but it has been found that by adding the hot liquid to the flask, or heating the contents of the flask before placing it in the machine. the same end is obtained.

The advantages of the machine over hand shaking are to the chemist only too obvious. During the time of shaking the operator can be doing other more profitable work, with the assurance that aside from being relieved from the fatigue of the operation the machine is not shirking the job—as is the natural disposition of mankind—resulting in false analysis, while with the machine the reverse is the case, it is always allowed to do its full quota of work. Then under its constant conditions, in phosphorus precipitation for instance, a precipitate of like crystalization is always obtained, aiding materially its estimation by judging its bulk, as is the practice in most busy open-hearth steel works laboratories.

Too much cannot be said in praise of the machine, its simplicity, ease of operation, quietness and the readiness with which the flasks can be placed in and removed from the apparatus, and the fact that the flasks do not need to be corked with the trouble that entails, will commend it to any one. Application has been made and the claims granted for a patent covering the ideas embodied in this machine.

Duquesne, Pa.

* A paper read at a joint meeting of the Pittsburg branch of the American Chemical Society and the Chemical Section of the Engineers' Society, at the Carnegie Tech. School, on May 23. The author is the chief chemist of the Carnegie Steel Co., at Duquesne, Pa.

The Effect of Stress Upon Corrosion of Iron.

As was already briefly mentioned in our report of the Philadelphia convention of the American Electrochemical Society, an account of an elaborate research on this subject was given by Prof. William H. Walker and Mr. Colby Dill, the investigation having been made at the Research Laboratory of Technical Chemistry of the Massachusetts Institute of Technology.

In the introduction of the paper the authors consider the corrosion of iron and steel as an electrolytic effect, and assume that a definite relation exists between electromotive force and corrosion. Then the corrosion of iron in water depends essentially upon three factors. These are the electrolytic solution pressure of the iron. the electrolytic solution pressure of hydrogen and the condition of the surface of the iron or metal which is in contact with the iron, in so far as it affects the ease with which molecular hydrogen may be liberated on it (so-called excess voltage). For any given experiment the two latter factors may be held practically constant, and the electromotive

force of the system made to depend for the greater part upon the solution pressure of the iron.

The paper deals with a single one of the conditions which are supposed to influence the e. m. f. of iron; it has received considerable attention of late, namely, the effect of stress upon the metal. The authors first review critically the work of Thomas Andrews (Proc. British Inst. Civil Eng., Vol. 118, p. 356, 1894), C. Hambuechen (Bull, Univ. of Wisconsin, Engineering Series 2, No. 8, 1900), and Richards and Behr' (Electromotive Force of Iron and Occluded Hydrogen, publications of Carnegie Inst. of Washington, 1906).

The investigation of the present authors was undertaken with the hope of throwing some light upon the question of the sign and magnitude of the potential changes caused by straining a piece of iron, particularly below the elastic limit. The magnitude of the increase of potential which one would expect to be produced can be easily computed on the assumption that the energy stored up in the specimen below the elastic limit is available as potential. Some very pure commercial iron (Swedish charcoal iron) was tested in the usual manner to determine the modulus of elasticity and the elastic limit. From these data the maximum amount of work which it is possible to do upon 1 cubic inch of soft iron by stretching it to its elastic limit was calculated to be 5.16-inch pounds, which is equal to 5.83 joules. One cubic inch of soft iron varies approximately 126 grams, the specific gravity being about 1.7. The work done in joules per equivalent is therefore 1.30, and the change in e. m. f. which would be expected is 1.30 joules divided by 96,540 coulombs, or 0.0000134 volt. The magnitude of this change is thus very small; its direction should be positive, because it is the manifestation of energy stored up in the metal.

The second part of the paper gives the results of experimental measurements made by the well-known method of Poggendorf, using a cadmium cell as standard e. m. f. The specimens of iron tested were made from two lots of exceptionally pure Swedish charcoal iron. One lot was of hard-drawn wire about 0.25 inch in diameter; the other was of bar iron about 0.50 inch in diameter. The bars were cut in lengths of about 18 inches, and the central portion reduced in a lathe for a distance of about 1 inch until a zone of bright new metal was exposed. This band was smoothed in the lathe first with a file and finally with emery cloth. With the exception of a narrow zone, about 0 25 inch width at the middle, the bars were covered with several water-proof coatings of ordinary shellac, to insulate the metal from the solution except at the desired point.

The cell consisted of a central tube about 3 inches long and 1 inch internal diameter, open at both ends. To this were bound by means of adhesive tape three smaller tubes of the same length closed at the bottom. The bottom of the central tube was closed by a rubber stopper, carefully cleaned, through which the iron part projected, so that the reduced portion came at the middle of the tube. The central tube containing the specimen was filled with ferrous sulphate and then the three outer tubes were filled, one with ferrous sulphate and the other two with potassium chloride. All four tubes were then connected by means of siphons. The siphon of the normal calomel electrode dipped into the last KCl tube. These precautions were successful in preventing the diffusion of the $FeSO_4$ into the tube containing the normal electrode. The $FeSO_4$ solution was protected from air by a layer of paraffine oil carefully washed to remove traces of alkali or acid. Fig. 1 shows the arrangement of the apparatus used during the tests.

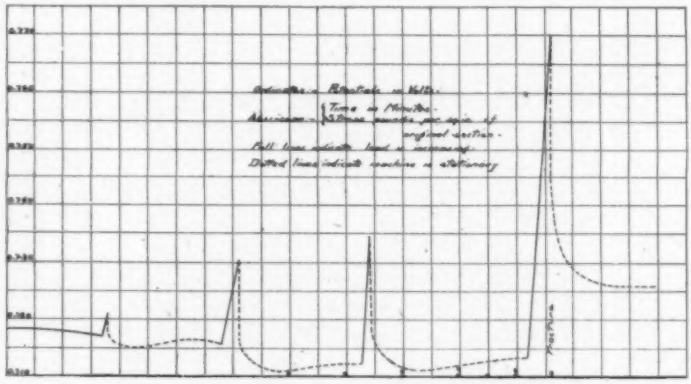


FIG. 2.—A TYPICAL RUN OF STRESS-POTENTIAL TEST.

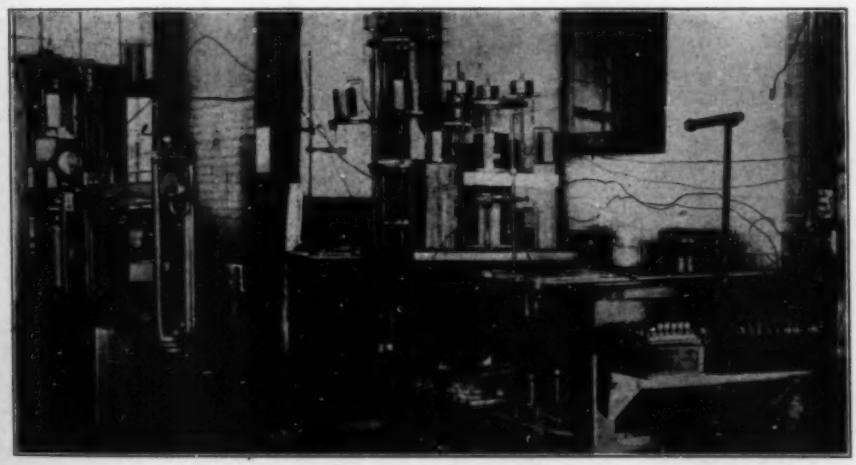


FIG. 1.—ARRANGEMENT OF APPARATUS.

Tests were made with a large number of pieces of iron which were subjected to increasing stress up to the breaking point, but it will be sufficient to give the results of one typical experiment. This is shown in Fig. 2. The curve gives directly the measured potentials in volts, the abscissæ representing the time in minutes during a test. The stress to which the iron was subjected is not given in the diagram in order to avoid complications. These figures will be given in the following description:

The stress was put on uniformly and gradually increased. The potential dropped simultaneously very slowly, until, at a stress of about 31,000 pounds per square inch of original section, the e. m. f. had decreased 0.9 millivolts. When the machine was stopped at this point the beam of the machine sagged. When stress was again applied the potential rose suddenly 3.9 millivolts, and when the machine was stopped it dropped to its former value in 15 seconds, then sank more slowly to a minimum and then started slowly to rise again. When load was put on a second time (41,300 pounds per square inch) the character of the change was similar to the first; there being first a sharp rise of e. m. f. while the load was increas-

ing, followed by an abrupt fall when the machine was stopped, then a slower fall, then a rise to a constant value. The magnitude of the sudden rise depended upon the rate at which the stress was applied. The curve in Fig. 2 shows the same behavior when stress was put on a third time (44,800 pounds per square inch), and the fourth time (up to fracture). The final value after fracture was in this experiment about 8 millivolts higher than the initial value. The arrangement of the test becomes quite evident from the diagram if one remembers that the full lines indicate that load is increasing while the dotted lines indicate that the machine is stationary.

The cause of the abnormal rise observed at high stresses was next considered. Change in temperature suggested itself as the most probable cause, although iron under these conditions has been shown to have a negative temperature coefficient. In order to duplicate as nearly as possible the thermal conditions which obtain in the iron electrode, a device was used whereby there was continual flow of heat from the electrode to the solution. A hole about ⅛ inch in diameter was drilled throughout the length of one of the electrodes. The upper end was joined by a rubber tube to a reservoir directly above, holding about 2 liters. A copper-nickel thermopile was soldered to the surface of the electrode where it was in contact with the liquid. Copper, nickel and solder were insulated from the solution by means of shellac. Hot water was placed in the reservoir and allowed to flow down through the electrode; the rate of flow was regulated by means of a screw pinchcock. The results of this test are shown in Fig. 3, from which it is evident that the rise of temperature produces a decided decrease of e. m. f. This experiment was repeated under certain precautions and entirely concordant results were obtained. This fall of potential, due to rise in temperature, explains the fact that the dotted curves in Fig. 2 fall below the normal potential of the iron bar.

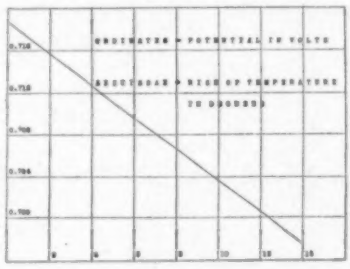


FIG. 3.—INFLUENCE OF TEMPERATURE ON POTENTIAL.

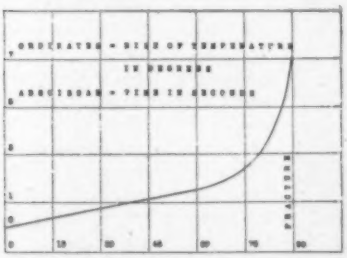


FIG. 4.—TEMPERATURE CHARGE UP TO FRACTURE.

If the sudden rise in potential above the elastic limit is caused by temperature changes in the electrode, then since iron has a negative temperature coefficient, the specimen must cool off as the breaking load is approached. Such a phenomenon, though highly improbable, is perhaps conceivable. Experiment showed, however, that there is a continuous rise in temperature from the elastic limit to the breaking load. The rise of temperature in this test was determined by means of the copper-nickel thermopile previously used. The junction was tightly bound by means of rubber bands to the reduced portion of the tension specimen. The results are shown in Fig. 4.

If there is a permanent difference in e. m. f. between a strained and an unstrained piece of metal, it should be apparent in the case of hard-drawn wire when compared with the same wire annealed. A number of samples of steel wire in its strained condition were obtained and portions of each sample carefully annealed in a vacuum. In almost every case a difference of potential was observed between the annealed and unannealed specimens. But further investigation showed that as great, and frequently greater differences, existed between the different portions of the *same wire*, both in the strained and in the annealed condition. This observation will form the basis of a subsequent communication.

The chief results of the investigation are summed up by the authors as follows:

1. The magnitude of the potential changes suffered by soft iron when tested in a tension machine below the elastic limit is exceedingly small. In the majority of cases it was less than 0.0001 volt. The maximum change was 0.0004 volt.

2. The change, when great enough to be measured, was negative, *i. e.*, the strained metal had a slightly lower potential than the same metal unstrained.

3. Somewhere above the elastic limit the potential rises suddenly several hundredths of a volt. The magnitude of the increase depends upon the rate of straining and ceases abruptly when the straining ceases.

4. Measurements upon specimens under torsional stress give results similar to those obtained from tension tests.

5. Out of a considerable number of specimens strained to breaking, the potential of six reached a constant value shortly after fracture. The difference between the initial and final potentials varied from —0.0019 volt to + 0.0077 volt, and the single potential of unstrained iron was found to be 0.156 volt.

Heroult Electric Steel Process.

In numerous articles in this journal details of construction of the Héroult electric furnace have been given, so that our readers are perfectly familiar with them. We are glad to reproduce herewith a number of views of one of the largest plants now in operation in this country using the Héroult process for the production of steel of highest quality.

The steel is made in an open-hearth furnace of the familiar Wellman type and is then refined in a Héroult electric steel furnace. The daily output is 60 tons. The capacity of the open-hearth furnace is 25 tons, that of the electric furnace is

FIG. I.—VIEW SHOWING THE OPEN-HEARTH FURNACE AT THE RIGHT AND THE ELECTRIC FURNACE AT THE LEFT.

4 tons. The open-hearth furnace works continuously. When 4 tons of molten metal are taken from the open hearth and supplied to the electric furnace, another 4 tons of scrap, etc., are charged into the open-hearth furnace. The treatment of 4 tons in the electric furnace is completed in 1½ hours.

From very exact tests made by Professor Eichhoff, he states that 200 kilowatt hours are sufficient for treating a charge of 5 tons if the overoxidized metal is supplied directly from the open-hearth furnace in molten condition to the electric furnace. If the price of the kilowatt-hour is assumed to be one-half cent—which is possible if cheap electric power is available at the steel works, for instance, from gas engines operated with blast-furnace gases—the total electrical energy necessary for the treatment of 5 tons in the electric furnace does not cost more than $1.00, or the cost of power in the electric-furnace treatment of 1 ton is not more than 20 cents.

If the charge would be supplied into the electric furnace in cold condition considerably more energy would be required, according to Eichhoff about 750 to 870 kw-hours. It is for this reason that the metal taken out from the open-hearth furnace should be furnished directly into the electric furnace with as little loss of heat as possible.

How this is accomplished in the plant illustrated in the accompanying figures is shown in Fig. 1, which gives a general

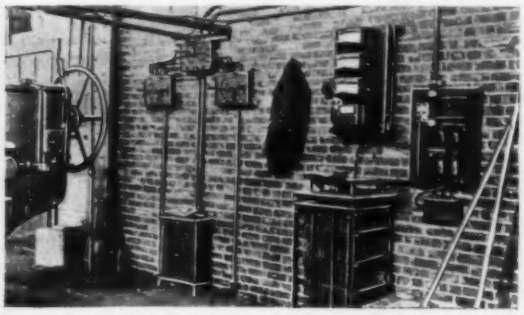


FIG. 2.—MEASURING INSTRUMENTS AND CONTROL APPARATUS.

view of the plant showing the two furnaces, side by side, close together, the open-hearth furnace at the right and the Héroult electric furnace at the left. Fig. 6 is the reproduction of another photograph taken from the other side and from a lower point; the electric furnace is again at the left and the open-hearth furnace at the right, while Fig. 5 shows the electric furnace placed high up on its platform. Fig. 4 is a front view of the electric furnace with spout, while Fig. 3 is a side view, showing at the right the apparatus for lifting or lowering the electrodes. The side door shown is used for charging and for making additions to the charge. Fig. 7 shows the electric motor and the gearing apparatus for tilting the electric furnace, Fig. 2, measuring instruments and control apparatus (from right to left main switch, the measuring instruments, and below them the rheostat switches, and at the left the apparatus for raising and lowering the electrodes, which is better shown in Fig. 3), and Fig. 8 the automatic regulator for adjusting the position of the electrodes.

While all other illustrations are self explanatory, a few words may be said concerning the automatic regulator. Since in the Héroult furnace the current passes from one electrode

FIG. 3.—SIDE VIEW OF ELECTRIC FURNACE.

into the slag on top of the metal, through the slag and out of it into the second electrode, it is important that the arcs between the end of each electrode and the slag are playing properly. If a rod of steel in contact with the molten mass (provided in the bottom of the furnace) is connected to two outside circuits, either of which leads to one electrode and contains one voltmeter, then each voltmeter is in shunt with its electrode, the arc and the fused metal and indicates whether there is the proper tension between the electrode and the metal. In other words, it indicates whether the arc is established in the proper way. A diagrammatic view of the connections was already given on page 287 of our Vol. I.). The indication of the voltmeter may, of course, be directly applied to automatic regulation of the position of the electrodes by electromagnetic means. For the principle of the method used the reader may be referred to the description of the same regulator used at the Héroult furnace in La Praz, described on pages 5 and 6, and illustrated in Fig. 8 of Dr.

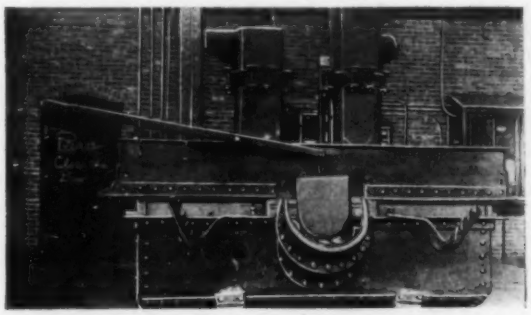


FIG. 4.—FRONT VIEW OF ELECTRIC FURNACE.

E. Haanel's report of the Canadian Commission of 1904.

Although so much has been written concerning the electrical features of construction of the Héroult furnace it seems that the essential metallurgical features of Dr. Héroult's method of working are not yet thoroughly understood. The following few notes are restricted to an explanation of the metallurgical and chemical principles of the Héroult process:

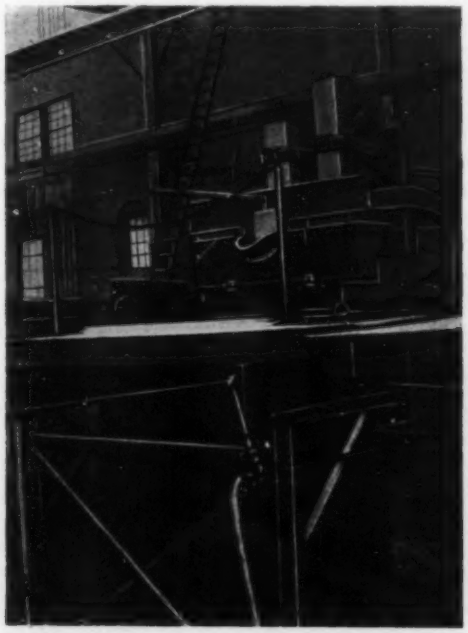


FIG. 5.—VIEW OF THE ELECTRIC FURNACE ON THE PLATFORM.

As explained before the whole process of making the steel consists of two stages: first, treatment in the open-hearth furnace; second, treatment in the electric furnace, and the success, and especially the economy, of the electric treatment depends to a certain extent on the right way of carrying out the previous open-hearth treatment. The operation in the open-hearth furnace is carried out preferably further than is usual in ordinary open-hearth practice. It can be carried on so long until the phosphorus in the metal has been reduced if

desired to, say, 0.005 per cent or even less. Now, it is well known that phosphorus is always eliminated after carbon. Hence, if we use the open-hearth furnace for reduction of phosphorus as far down as just stated, we necessarily also eliminate the carbon and at the same time highly oxidize the metal. This would be very undesirable in ordinary practice, but the product thus obtained from the open hearth is exceedingly suitable for the subsequent treatment in the electric furnace.

FIG. 6.—GENERAL VIEW OF THE OPEN-HEARTH FURNACE (AT THE RIGHT) AND THE ELECTRIC FURNACE (AT THE LEFT).

What is introduced into the electric furnace from the open hearth is a molten, highly oxidized metal, exceedingly low in phosphorus and carbon. What the electric furnace must accomplish is essentially the deoxidation of the metal, its recarburization and the elimination of the sulphur. All this is attained successfully in the Héroult process, which yields a product containing any desired percentage of carbon, with less than 0.01 sulphur and phosphorus, free from oxide and slag. Prof. Eichhoff has called attention to some special chemical reactions which take place in the Héroult furnace, and only in this furnace, and which are of special interest in this connection.

The removal of sulphur is possible on account of the possibility of selecting slags which would not be sufficiently fluid at lower temperatures but which can be used at the high temperature of the Héroult furnace. There is no danger that the charge might be spoiled by this high temperature, since the charge is continually in rapid circulation and all particles in the bath are brought into contact with the slag, the highest temperature being concentrated in the layer of slag.

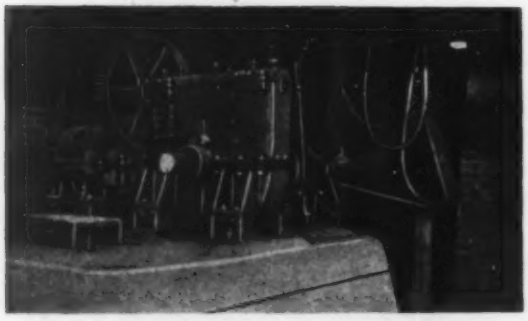


FIG. 7.—ELECTRIC MOTOR FOR TILTING THE ELECTRIC FURNACE.

With respect to deoxidation it should be emphasized that this is obtained in ordinary practice only with very great difficulty and expense. On the other hand, if iron oxides are dissolved in the steel they cause pipes and blow-holes. To prevent them ferro-manganese and ferro-silicon are ordinarily added, but while largely successful, they have the disadvantage that the resulting oxides of manganese and silicon are solid and remain in the steel in a finely divided state in form of an emulsion. Further, as long as the slag contains iron oxides in solution they will react with the molten bath, and thorough deoxidation of the bath is impossible. The neutral slag used in the Héroult furnace is perfectly free from iron, and this is a very important point.

Ferrous oxide and iron carbide can exist together, and for this reason complete deoxidation is not possible under ordinary conditions by means of adding carbon, but this is possible with the Héroult process, since the addition of carbon to the slag results in the formation of calcium carbide, and therefore the deoxidation can be carried on much further than is possible otherwise. For this reason only the least traces of ferrous oxide need be rendered harmless by means of manganese. This is introduced by adding a certain quantity of manganese ore to the slag. The metallic manganese reduced by the carbon present reduces the last traces of ferrous oxide in the bath. No reoxidation is possible, since the bath is protected by the slag from the atmosphere.

It is, of course, possible to treat in the Héroult electric steel furnace any ordinary steel made in the open hearth or converter, but the phosphorus would not have been reduced to such a low percentage in the open hearth and the electric steel furnace would also have to accomplish this end. In such cases first an oxidizing slag is placed on top of the molten charge

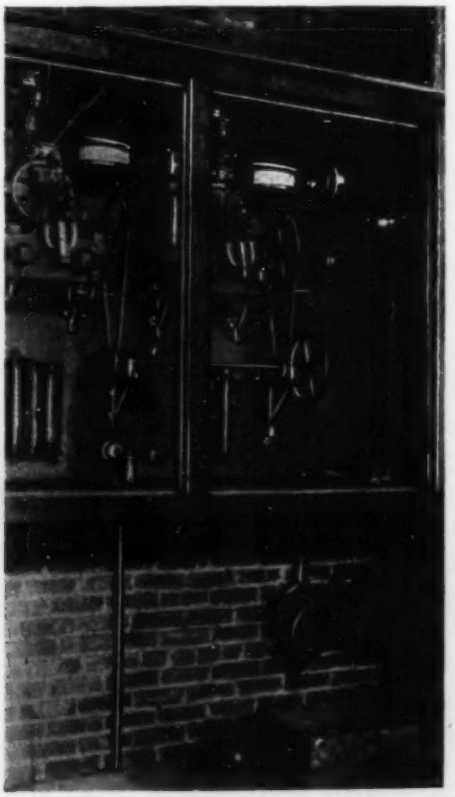


FIG. 8.—AUTOMATIC REGULATORS FOR ELECTRODES.

when introduced into the electric furnace, and after it has performed its work the slag is taken off and carbon and a neutral slag is introduced as described above. Of course, in this case the electric furnace treatment consumes more time and more power, and it has been found to be economical in general to carry out the process as described before.

However, from the nature of his process, Dr. Héroult is free to carry out the preliminary open-hearth treatment to any desired extent so as to make the whole treatment, that is, the combined open-hearth and electric process, as cheap as possible, so as to fit as closely as possible any case of practice.

It is apparent that in case the purposes for which the finished steel is to be used do not require the elimination of phosphorus and sulphur and the refining process to be carried out to the very highest point, as is necessary for the finest grades of tool steel, then such steel can be produced in the combination Héroult process at but a very slight cost above that of making an ordinary basic open-hearth steel, and even in the case of producing the finest grades of tool steel the additional cost of operation to reach that point is but a small item in the whole cost of production.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our Special Correspondent.)

THE IRON AND STEEL INSTITUTE MEETING.

First Day.

The London meeting of the Iron and Steel Institute, which is one of the chief events of the year in metallurgical circles, was attended by the usual numerous audience. At the outset it fell upon Sir James Kitson, as senior vice-president, to induct Sir Hugh Bell to the presidential chair, it being impossible for Mr. Hadfield, the retiring president, to relinquish his honors in person owing to his absence in New York as a delegate at the opening of the Engineering Building. In introducing Sir Hugh Bell (the formal business being over) Sir James Kitson explained that real merit, and not the glory of an inherited name, was the reason for the elevation of a son of Sir Lowthian Bell to the position of president.

After presenting the Bessemer gold medal to Mr. J. A. Brinell, Sir Hugh Bell delivered a presidential address of great charm and high literary merit, which contained an appendix giving a chronological table of "some of the more important events connected with iron and steel during the past hundred years." Of the address itself the most striking part was that which discussed the relation between transport facilities and metallurgical processes, and the reactions and interactions of these forces, and the influence of the factor of intervening distance, which is becoming less and less of a barrier. Then, too, it was hinted that perhaps even the Bessemer converter was about to be superseded by the open-hearth furnace, and that a continuous process might yet displace all intermittent ones.

Passing next to the human element, it was pointed out that "those to whom were due the great improvements which 100 years ago were beginning to be effected were, on the whole, men who owed little to schools or colleges. "Self-made," as the expressive phrase goes, it was to their indomitable courage and energy that they owed success; to these and to that inborn perception of the possibilities presented to them which school or college seems to do nothing to create and little to strengthen. But the first barriers broken down and the pioneers having shown the way, the carefully trained mind is needed to make straight the path. It must be admitted that we in this country have been disposed to neglect that careful training of the mind, and to rely on the native powers of insight more than on the trained intelligence. The workshop rather than the college was the technical school in Great Britain. As the tools in our possession become more complicated we must be better trained in their use. The empiric skill of the native genius, where imagination stands instead of knowledge, gives place to the learning acquired by the patient student at the technical school, and science supplants art at furnace and in workshop. If we in this kingdom are to keep our place in the world of industry we must be ready to make use of the changed methods, as our grandfathers were ready in their day to avail themselves of the forces newly placed at their disposal. For we, as they, look out on a world of perpetual change."

The vote of thanks was moved by Sir William White, who spoke of the use of steel in shipbuilding and its division into epochs, the third of which, that of high-tension steel, was now commencing. It was seconded by Mr. Schneider, of Creuzot, and after acknowledgment by Sir Hugh Bell the reading and discussion of the papers commenced. [Abstracts of the papers themselves are printed on another page of this issue.—EDITOR.]

DISCUSSION ON ELECTRICALLY-DRIVEN REVERSING ROLLING MILLS.

Mr. D. Selby Bigge, with commendable brevity, did better even than the new procedure rules (which allow 10 minutes to the authors of papers) by limiting his introduction to 6 minutes.

Mr. Gledhill welcomed the paper as one of considerable importance, but in some respects depressing, as he had personally put down about five years before a 10,000-hp. triple-expansion engine for driving a reversing armor plate rolling mill. He feared the engine was obsolete, and chaffingly invited bids from the audience. No responses being forthcoming, Mr. Gledhill alluded to the intermediary links between the power house and the rolls as numerous and complicated. The matter was wholly one of economy, and the steady load afforded was one suggesting economy.

The succeeding speaker, Mr. Kerlew, was imperfectly heard, owing to his rapid delivery of a mass of figures recited at such a race that no clear line of argument could be understood. The speaker's hostility to electric driving and frank preference for the direct-coupled steam engine was, however, easily apparent.

Mr. Arthur Cooper remarked on current practice in this country, contrasting the three-high rolling mill with its heavy fly-wheel and liability to breakdown, and the reversing mill with its simple but extravagant steam engine.

Mr. Walter Dixon remarked that he was employing the Ilgner system in a case where the load conditions were not unlike those in rolling mills. The whole advantage of the Ilgner system lay in its equalization properties of rendering an intermittent demand for power a fairly continuous load at the power station. This point was further emphasized by a lecture by Mr. Robert Hammond on the importance of studying load factors. Mr. Hammond raised the only point of electrical detail by criticising the water resistance used in the control of the three-phase motor on the conversion set, and suggested that conversion should take place earlier so that direct current was used on the motor-fly-wheel-generator combination.

Mr. A. W. Richards criticised the extreme length of the Ilgner apparatus as an important drawback for existing works, and asked what capital outlay would be actually involved with the reduction in coal consumption following its adoption.

Mr. F. W. Paul remarked very bluntly that it was possible but equally futile to talk all day about pounds of steam. The methods described in the paper marked a trend in the right direction. Mill stoppages could not be obviated in steel works management. Cogging mills were idle for hours at a time. They should ask themselves in each steel works, how many mills, how are they grouped, what is the load Then the mani-

fest solution was a central power station with its improved works load factor.

Mr. Tannett Walker and Mr. Lamberton having spoken, Mr. C. H. Merz wound up the discussion by pointing out that in the first place the question was not necessarily one of steam consumption. Acceleration had to be considered, and extra rapidity of mill working would be secured. Finally, there was the case of load factor.

Mr. Selby-Bigge's brief reply may be summarized as a promise to answer all the questions leveled at him in the shape of a reply at the Vienna meeting.

By this time it was too late to discuss any further papers and the meeting therefore adjourned until next day.

The Faraday Society's Meeting.

A fairly well attended meeting, with Prof. Huntingdon in the chair, on May 24, had before them two papers and a demonstration by Dr. Lowry of some new thermostatic appliances. Mr. F. H. Campbell's paper, "Contributions to the Chemistry of Gold." was introduced by Mr. Wilsmore and accorded a brief discussion, the chief point being an exceeding interesting communication from Prof. Abegg, pointing out that the peroxides of the more noble metals were unstable, splitting off their oxygen at high pressure, and alluding to Dr. Cumming's recent paper on the "Electrochemistry of Lead." The point of special interest being that AuO_2 and PbO_2 had both the same hydrogen pressure. Dr. Borns remarked that Mr. Campbell had not referred to Wohlwill's work on the subject, and inquired whether the respective conclusions were in agreement. For instance, Wohlwill had emphasized the necessity for an excess of HCl. Mr. Wilsmore, speaking on behalf of the author, regretted his inability to give any information beyond that contained in the paper.

Dr. F. Mollwo Perkin, speaking without any notes, gave a most interesting description of a research upon "The Reduction of Oxides and Sulphides by Metallic Calcium." As the paper has not yet been circulated an outline of its contents is perhaps not out of place. Opening with a reference to the well-known reducing action of aluminium and certain oxides in welding process, Dr. Perkin described several experiments. Desiring to obtain boron he had tried boric oxide and aluminium. These mixtures had failed to ignite, and the experiments were very uncertain, and the element's danger involved suggested to the audience (not. of course, from Dr. Perkin's lips) that the hazards of the mediaeval alchemist were an unavoidable concomitant of all research upon these lines. As metallic calcium used with sodium peroxide gave a violent action, he had therefore used from 5 per cent to 10 per cent of calcium oxide and had obtained an impure amorphous boron. The impurity was calcium in the proportion of about 20 per cent, which could not be reduced to less than 20 per cent after prolnged digestion with hydrofluoric acid. Calcium was more powerful than aluminium, but very violent, and if used to reduce MnO_2 the action was pyrotechnically brilliant. Calcium fluoride or calcium oxide diluted the action if it was desired to reduce chromium. In order to save breaking crucibles to get out the reaction product, the crucible was lined with a paste of slaked lime and sodium silicate, which was quite successful.

Aluminium and galena in molecular proportions gave lead and aluminium sulphide. Substituting calcium for aluminium, calcium theo-plumbate was obtained but not lead. Also, with calcium and stibnite, no metallic antimony was obtained. In conclusion, Dr. Perkin said that he was continuing his experiments, that calcium was too dear at present for commercial use, and that he hoped to obtain boron free of calcium.

In the discussion which followed, Mr. W. M. Morrison pleaded that he "had been too busy manufacturing aluminium to experiment with it." "Perhaps Dr. Goldschmidt had found some special proportions for his mixture." "Had Dr. Perkin tried an excess of boron oxide?" Dr. Borns observed that the violent action observed by Dr. Perkin had been noted ten years before. Mr. Weston said that in attempting the reduction of silicon with aluminium he had met with success by using kieselguhr and aluminium, and had obtained appreciable quantities of silicon tetrachloride. He wanted to know whether metallic calcium could be obtained in powdered form. He had recently been successful in using aluminium to reduce titanium compounds. Mr. Digby asked leave to take the discussion from the laboratory to the steel works, as he had lately been much vexed by segregation in large steel castings. Was enough known for any one to say whether metallic calcium added in small quantities to the metal in the ladle before pouring was a satisfactory remedy? This speaker was directly answered by Prof. Huntingdon. who said that he did not regard the proposal very favorably as, in experiments made, the calcium oxide formed was undesirable, and occasioned other difficulties. As regards Dr. Perkin's paper, Prof, Huntingdon said it was very useful and very suggestive. The fineness and state of division of the silicon used was an important factor.

Dr. Lowry then exhibited some new thermostatic apparatus, and described the chief features of the ordinary mercury at Ostwald gas regulators. In the latter the expanding liquid was a strong solution of calcium chloride (with a coefficient of expansion equal to mercury) rising against a column of mercury. With regard to the early forms of toluene regulator the taps were a failure and would not keep tight, and therefore it was necessary to prevent the toluene coming in contact with the tap, which if kept in contact with the mercury permitted adjustments to be made. In order to have a sensitive regulator, fluted or spiral tubes were used, the latter being best. Under the control of a spiral pattern regulator, the liquid not being agitated, the temperature variations showed an extreme of 0.02° C. with a 5-minute period of oscillation. If, however, the liquid in the bath was kept in a condition of continuous movement, the variations became so minute as to be only thousands of a degree Centigrade. Usually, with all thermostats, it was necessary to reset them from day to day, and the mercury had to be kept very clean. But with a spiral pattern tube and continued movement of the water in the bath, a thermostat adjusted at 19.995° C. in October only increased its point of regulation in six months to 20.020. Water-jacketed polarimeter tubes could be regulated by controlling the water temperature in a big bath, the contents of which were well stirred; the water in the bath could be kept constantly within 1/100° C. In the form exhibited at the meeting, the loss of temperature in pumping through two thermostats was 1/100° C. per thermostat.

At the close of the demonstration, apart from the well-deserved vote of thanks, only two comments were made. Mr. Wilsmore suggested that chloroform might be used instead of toluene with water on top in a safety funnel, and also mentioned Dolezalek's regulator which worked within .02° C. Dolezalek had used vigorous stirring. Dr. Cumming said that at Edinburgh he had seen an electric glow lamp inside a bath used instead of gas. Its chief disadvantage seemed to be that it had to be controlled on a shunt.

The Finances of the British Aluminium Co., Ltd.

The report of the directors of the British Aluminium Co. showed the profit for 1906 to be £155,023.13.6. with £3,880.1.11 from the previous year, the total available profit being £158,903.15.5. The directors recommend payment of a final dividend on the preference shares for 1906, interest on the funding certificates for 1906, 5 per cent interest on the conversion shares to Dec. 31, 1906, and a dividend of 7 per cent on the ordinary shares for 1906, leaving £34,548.11.9 to be carried forward. During the year progress has been made with the development of the Loch Leven power scheme. By Aug. 15, 1908, all the generating plant should be installed and the aluminium factory erected and equipped. With a view to obtaining an increased production of aluminium prior to the completion of the Leven

works the board acquired a partially developed power at Stangfjord in Norway, and took steps to develop some 3,000 hp. at Leven, which latter can be utilized without interfering with the progress of the main chance. It is expected that the production of aluminium will commence in Norway in a few weeks' time and at Leven in the autumn. The board has also acquired concessions for a water power of considerable magnitude at Orsières. in Switzerland, and intends to proceed with the construction of works without delay. These extensions involve large expenditure, and the share capital has been increased by £600,000. An agreement has been come to with the Soc. Anon. Pour l'Industrie de Neuhausen to end all outstanding provisions of the 1895 contract upon paying to the Neuhausen Co. £100, and engaging for a maximum period of ten years, from Jan. 1, 1907, not to use or permit to be used any part of the Orsiéres water power for the production of aluminium.

INSTITUTION OF MINING AND METALLURGY.

COPPER SMELTING.

Prof. Gowland's inaugural presidential address to the Institution of Mining and Metallurgy was an excellent example of an address of monograph order, epitomizing, as it did, "The Chief Advances in Copper Smelting in Modern Times." Naturally, it embraced many fields, and surprising, indeed, has been the transition from the time when Great Britain was the chief copper producing country in the world. Opening with statistical data, Prof. Gowland traced the growth of the world's total production from 56,200 tons in 1854 to 689,277 tons in 1905, a development due to the following features: A remarkable increase in the size and capacity of the furnaces employed, whether reverberatory or shaft; the application of the Bessemer process to copper mattes; the introduction of raw sulphide or pyritic smelting, and the reduction in the costs of producing the metal, which have followed and are dependent on the foregoing, and last, but not least, the removal of the chief producing centers from the old world to the new.

Methods of calcination, types of blast furnaces were described in detail, some vivid Japanese drawings being reproduced as typical of a rudeness of manufacturing method approaching the prehistoric. Pyrite smelting reverberatory furnace and Bessemerizing were described in detail. As to the future of this important industry it is perhaps best to quote Prof. Gowland's exact words.

"Advances as great or perhaps greater than those of the last fifty years will be made before the end of the next half century, and although it is impossible for us to foresee in what direction they will ultimately lie, yet, so far as present indications are concerned, I think we may, with some degree of reason, consider that the following at least will play a not unimportant part:

"(a) The extended application of producer gas as fuel in copper reverberatory furnaces. This would, I feel sure, be found to be specially efficacious with large furnaces such as those of the Anaconda Co. Gas could be admitted at several points in their sides and so secure a uniformly high temperature throughout their length.

"(b) The introduction of the tilting furnace of the open-hearth steel manufacturer into the copper refinery. A movement in this direction has already been made at the Tacoma Refinery, Puget Sound, but oil and not gas is used as fuel.

"(c) The extended adaptation of the Bessemer converter to the treatment of poor copper matte, etc. Even now, with a basic lining and the addition of silicious ores of value to the charge, a certain amount of success has been attained in this direction, but this is only an earnest of what may ultimately be reached.

"(d) The roasting of cupriferous pyritic ores in cast-iron vessels with a blast and additions of silica or lime.

"(e) The utilization of the sulphur dioxide from the poor gases from calcining and roasting plants for the manufacture of sulphuric acid by a 'contact' process.

"(f) Lastly, but by no means least, the electric smelting of copper ores where water power for generating electricity can be obtained at small cost. This process at present, however, has not passed out of the experimental stage.

"I have purposely confined my attention to furnace processes only, as the increased production of copper has been almost solely due to them. In future, however, electrolysis may be expected to play an important part, not only in the refining but also in the extraction of the metal from ores or mattes."

METALLURGICAL PAPERS READ IN APRIL.

DESULPHURIZING COPPER ORES.

The April meeting of the Institution of Mining and Metallurgy had four papers presented for discussion. The first, by Dr. F. H. Hatch, described "A Visit to the Gold Fields of Orenburg. Russia," and dealt with the geological features of this district, together with the primitive methods in vogue. Mr. T. C. Cloud next communicated a description of "The McMurty-Rogers Process for Desulphurizing Copper Ores and Matte." The following extracts summarize the chief features of this process.

The converters used for burning the ore which have been installed at the Wallaroo Works, are cast iron pots mounted on trunnions and inverted by means of a worm and wheel, the inside diameter being 8 feet 8 inches by 4 feet 6 inches deep, the false bottom slightly convex and placed about 10 inches from the lowest part of the converter; it is perforated all over with 5/8-inch holes. Originally these false bottoms were made of cast iron, but it was found better to use wrought iron plates strengthened with angle-irons underneath, these bottoms being held in position by a bolt passing through the center of the pot.

The *modus operandi* consists in first covering the false bottom with pieces of a previously burnt charge broken to from 3 to 4-inch size, then lighting a small fire in the middle of the pot on the top of this burnt material, using a light blast to urge on the fire, then charging the ore on top of this fire till the pot is about half full; after increasing the blast, and when the ore becomes more or less red in several places, the balance of the charge is added till the pit is full.

When the ring of fire has reached about one-third to half the diameter of the pot the ore is charged in on top, the first being put on with a shovel so as not to scatter the fire too much, but after a layer has covered the whole of the bottom the ore is then fed in by an elevator from the feed bins below, being spread by a man over the surface in such a way that when the pot is half full the ore is piled up more at the sides than in the middle, presenting a concave surface; the reason for this being that the fire has a tendency to make for the sides rather than up through the middle.

For some time coal was used, or a mixture of coal and fine coke, but sawdust was found to answer better, as the fire was not so hot.

When the pot is about half full and the charge distributed as stated, a number of holes are pricked near the center a slight distance down into the charge with a ½-inch rod; the object of this being to give more or less free vents for the uncombined sulphur and sulphur dioxide to escape and so quicken the burning. These holes must be closed in before the fire burns through, otherwise blow-holes would be formed; the man in charge soon learns to tell when the fire is getting near the top of any hole by the color of the smoke given off.

During the spreading of the charge the blast is usually turned off to enable the man to work comfortably, and after the holes have been pricked, half-blast is given for about an hour, being then increased to full pressure.

The full pressure of the blast used is 13 ounces, but it can be largely increased if necessary; over 20 ounces has been used, which latter pressure quickens the time of burning. The

volume of air used per minute at this pressure for each pot is about 1,000 cubic feet.

Each pot has to be covered by a hood in order to take off the fumes, a connection being made from the hood to a flue, or a large pipe taken out from the top of the hood through the roof of the shed. When the evolution of sulphur dioxide slackens and the charge has become red-hot throughout, the blast is turned off, the blast pipe disconnected and the converter inverted.

The elimination of sulphur is as good as is obtained by most calcining processes for copper ores, and if the sintered product were smelted alone, without the addition of some uncalcined ore, the regulus produced would be too high for good work.

The result of a sample from a large pile waiting for blast furnace treatment gave 5.65 per cent of sulphur; other results have given under 5 per cent of sulphur from raw ore containing about 20 per cent of sulphur and 10 and 12 per cent of copper.

The first experiments were made during 1904, and at the present time the plant which has been installed at Wallaroo is treating from 400 to 500 tons of ore a week.

Regulus or Mattes.—In treating these products the addition of some silicious material is necessary in order to take up the iron contained and form ferrous silicate; the proportions to be used are, preferably, from 15 to 25 per cent, but these may vary considerably. The silica may consist of such materials as coarse sand, jigged tailings, silicious carbonate ore, silicious oxide ore, and even silicious sulphide ore, such as dressed ore from buddles and Wilfley tables, has been used. The regulus should be crushed to pass a screen with meshes of from ½ to ¾ inch square; with soft mattes the larger screen should be used, but with hard low-grade mattes it is better to take the ½-inch size.

The starting of a regulus charge does not need as large a fire as in the case of ore, and very good results were obtained by using the lead kettles previously mentioned for this work, starting the fire with a little wood and sawdust on the top of the rough pieces of burnt material; the pots which are in use for the burning of rich regulus or "regule," to be subsequently described, were also found to give very good results in matte burning, as the product, being smaller, was easier to break up than the large cakes obtained from the lead kettles.

The blast used must not be too high, 6 to 8 ounces being enough at first, as the lower layer next to the fire is apt to run up to too high a temperature if a greater pressure is maintained at starting; the pressure can, however, be increased towards the end to the same extent as with the ore.

"White Metal" or "Regule."—The most satisfactory results obtained were with "metal" assaying from 78 to 80 per cent of copper, that grade known as "spongy regule" being the best owing to its porous nature.

By using the converter process for this operation the same end is obtained as far as the subsequent refining is concerned, but the troubles in the calcining are largely overcome and a more suitable product obtained for charging into the refining furnaces, and being in a lump form less loss from dusting.

Against this more slag is produced than is the case with the Nicholls and James process, but the elimination of the impurities is decidedly better than is obtained by treating "regule" by either the ordinary Welsh roasting process or the Nicholls and James process; this latter fact is of great importance where the better classes of copper are required, as, for instance, "Best Selected."

The final product obtained consists essentially of porous metallic copper mixed with oxide sulphate, and some unchanged regule, and for some time the main trouble was to break up the mass; this, however, was overcome by using a heavy iron ball weighing about 16 cwt., which was hoisted up by a steam winch 20 feet high, and allowed to drop on the sintered regule product; a few blows generally served to divide it into several pieces, which could be further reduced if necessary by the use of a sledge hammer and gad.

The third paper of the evening was that by Mr. G. T. Holloway, describing some "Laboratory Crucible and Muffle Furnaces," which had stood the test of nearly six years' uninterrupted use. Lack of space prevents my summarizing this paper.

The same cursory dismissal must be accorded to an interesting paper on "The Ironstone of Cleveland." by Mr. Arthur E. Pratt, which deals with this ore from the mines to the completion of its calcining in the kilns.

Market Prices During May.

In the chemical trade the following closing prices have to be chronicled: Copper sulphate, £33.10 per ton; ammonia sulphate, £11.17.6 per ton; potassium carbonate, £19 per ton (a further decline of 10s. 6d.), Montreal potash (in store, Liverpool), £40 per ton. Shellac is unchanged at £10.19.

In the metal market, copper, after advancing from £104 to £106.10 on May 1, receded steadily to £101.10 on May 8, and remained in this neighborhood until May 24, when it fell abruptly to £98.5 on May 28, rallying next day to £99.12.6, and closing on May 1 at £101. Tin stood at £195.15 on May 1, fell to £192 on May 3, recovered to £193 by May 13, and receded to £189.5 by May 15. An upward spurt of £192 on May 24 was followed by an abrupt decline to £187 on May 28, recovering to £190 on May 31. English lead has been steady, closing at £20.10. Antimony is easier at £67 to £70 per ton, owing to supplies from new sources which have relieved the scarcity of a few months ago. Platinum is easier at 110s. per ounce; thanks. also, to new sources of supply.

The rise in iron prices was well maintained until May 14, by which date Cleveland pig iron stood at 62s. 8d., and hematite at 81s. 10d. Irregular prices and a downward tendency resulted in a fall in Cleveland pig iron to 59s. 6d. on May 26, with a subsequent recovery to 61s. 10d. Hematite fell to 78s. on May 26, and recovered to 78s. 6d. on May 30.

London, June 5, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS.

Electric Furnaces.

Low-Carbon Ferro-Alloys.—E. F. Price, 852,347, April 30, 1907. Application filed April 14, 1905.

The object is the production of low-carbon ferro-chromium, ferro-manganese, ferro-titanium, ferro-vanadium, etc., by the use of ferro-silicon as reducing agent. The first step of the process is therefore to produce ferro-silicon high in silicon and low in carbon by electrically smelting a charge of silica, iron ore or iron and carbon. This is done in furnace 1 of Fig. 1, the walls 2 of which consist of siloxicon, carborundum or carbon, while the hearth 3 is made of carbon. The furnace is surrounded by a metal casing 4 with an electric terminal 5. The depending carbon rod 6 constitutes the other electrode; 7 is the tap hole for slag and 8 is the tap hole for metal. The charge consists of finely ground silica, iron ore and coke, the silica and carbon being used in relatively large amounts. The molten ferro-silicon collects in the bottom of the furnace and is run through the tap hole 8 into the reduction furnace 9, which is lined with chromite or magnesia and also surrounded by a metal casing 11.

When ferro-silicon has been tapped into this furnace so as to provide the molten layer 16, arcs are established between the electrodes 14, 15 and this body of ferro-silicon, and the charge 17 containing the ore to be reduced (for example, a mixture of chromite with a basic flux such as lime) is fed into the furnace. The silicon in the molten silicide effects the reduction of the

chromite and is converted into silica, which combines with the lime to produce a fusible slag. The reduced chromium and iron alloy with the residual iron of the silicide and the slag accumulates upon the molten alloy as a floating layer 18. When reaction is finished, sufficient chromite being present to insure the oxidation of substantially all of the silicon, the slag and alloy are withdrawn through the tap holes 12, 13. More of the ferro-silicon is then tapped from the furnace 1, percolating through the hot unreduced charge in the furnace 9. The second stage of the process may be conducted in a continuous manner by retaining a pool of metal in the furnace 9, maintaining the arcs, and supplying the charge and molten ferro-silicon and withdrawing the slag and ferro-alloy as required.

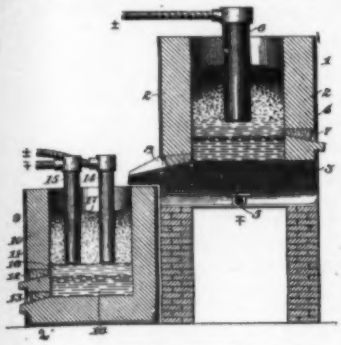


FIG. 1.—ELECTRIC FURNACE FOR FERRO-ALLOYS.

Electric Steel Furnace.—P. L. T. Héroult, 12,658, June 4, 1907. Application filed March 3, 1903. Assigned to Société Electro Metallurgique Française.

This patent refers to Dr. Héroult's well-known steel furnace, which may also be used for the production of soft metals, such as chromium, manganese and generally substances which tend to combine with carbon. There are two vertical electrodes passing through the top of the furnace yielding two separate arcs in series, each arc being formed between the end of one electrode and the slag on top of the fused bath. In order to insure the distinct formation of these two arcs two accessory circuits are arranged, connecting outside the furnace each of the two electrodes to the fused material, and in each of these circuits there is introduced in shunt a voltmeter, the indications of which serve to constantly verify and regulate the position of both electrodes and to determine whether or not the furnace is operating properly. (See our Vol. I., page 287, Fig. 1). Thus either by hand or by automatic mechanism operated by the two shunt currents each electrode can be raised or lowered to determine the arc, as desired. "When the arrangement is applied to the manufacture of steel or melted iron, there is directly obtained in the crucible metal decarburized by the slag, and the reducing gases in passing through the soft ore between the electrodes so act that the ore is partly reduced before undergoing electrical fusion. Cast iron can also be decarbureted or dephosphorated by the use of reagents according to the Thomas process." When the furnace is used for the production of metals "the slag is mostly imperfectly reduced mineral matter, or if the furnace be used to obtain stability of composition of mixtures of fine steel with other elements—such as chromium, nickel, tungsten, etc., the slag is composed chiefly of reagents designed to act on the bath of metal—such as lime, dolomite or oxide of iron liquified by the addition of silica—or it may be substantially neutral, such as a fusible silicate, which has no chemical action on the bath." The voltmeter terminal which communicates with the material in the crucible is a rod of the same metal as that being produced in the crucible, and is built into or passes through the refractory wall of the crucible into the material within the same. When the rod melts the space or hole which it leaves in the wall is filled with molten conducting material, the extent of fusion of which is limited by the proximity of the cold exterior wall. The current carried by this terminal is only a few milli-amperes.

Reduction of Iron Ore.—H. W. Lash, 856,351, June 11, 1907. Application filed Oct. 13, 1905.

The inventor treats a mixture of finely divided iron oxide (such as magnetic concentrates) with finely divided cast or pig iron and finely divided carbon (ground coke) and a flux. The addition of some sawdust is advantageous. The metallic portion of the charge may be shotted or granulated cast or pig iron, or finely divided cast iron obtained from any source. It is, however, to be noted that this iron must be of the quality commonly designated as cast, or pig iron, as distinguished from the ordinary run of scrap, wrought iron or steel, since it is important that it contain a high percentage of metalloids or easily oxidizable metals, such as manganese, capable of uniting with the oxygen of the ore. At the temperature available in the electric furnace the sawdust or readily combustible material, if present, disappears as such, leaving the mass to a certain extent porous. Upon the continued application of heat the metalloids and easily oxidizable metals contained in the cast iron and a portion of the carbon of the carbonaceous additions unite with the oxygen of the oxides present, thus reducing the iron oxides to metallic condition. The inventor states that he has obtained a recovery of 98.1 per cent of the iron with a charge made up of 16 parts by weight of iron ore, 16 cast iron, 2 carbon, 0.5 limestone, 0.5 fluorspar, 0.5 sawdust (total 35.5). He states that he obtained a recovery of 100 per cent of the iron with a charge made up of 18 parts by weight of iron ore. 7 cast iron, 2 carbon, 0.25 limestone, 0.25 fluorspar, 0.5 sawdust (total 28).

Cooling Electric Furnace Electrodes.—F. M. Becket, 855,441, June 4, 1907. Application filed January 30, 1906. Assigned to Electro Metallurgical Co.

The oxidation and destruction of carbon or graphite electrodes is prevented by artificially cooling them by means of water-jackets, as shown in Fig. 2. The two vertical openings 3 in the roof of the furnace contain the cooling jackets 4 of iron, which in turn receive the electrodes 5, 6. To the upper end of each jacket are connected pipes 7, 8 carried by the bracket 9, which is adjustably mounted on a vertical rod 10. The pipes 7, 8 serve both as a means of adjustably supporting the jackets 4 independently of the furnace roof and electrodes and for the supply and discharge of cooling water.

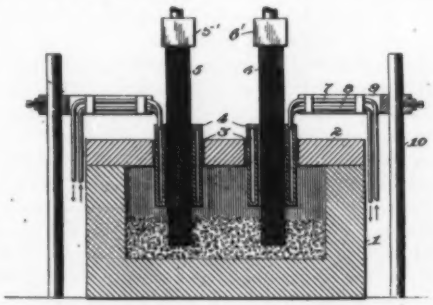


FIG. 2.—COOLING JACKETS FOR ELECTRODES.

ELECTROLYTIC PROCESSES.

Calcium-Zinc Alloy by Electrolysis.—F. von Kügelgen and G. O. Seward, 856,075, June 11, 1907. Application filed March 30, 1905.

Molten calcium chloride, $CaCl_2$, is electrolyzed with a cathode of molten zinc at the bottom of the vessel. The calcium set free at the cathode alloys with the zinc. Calcium and zinc alloy in almost any proportion and all such alloys except those containing very little zinc are heavy enough to remain at the bottom of the cell, where the alloy is unattacked by the chlorine which is liberated at the carbon anode in the top of the vessel. The vessel may be of cast iron, and in this case the molten zinc cathode may be connected through the bottom of the iron vessel with the negative terminal. In this case no portion of the walls of the iron vessel should act as cathode.

This may be prevented by water jacketing the walls of the vessel so as to produce a solid layer of calcium chloride which protects the iron walls. The calcium-zinc alloys are stated to be advantageous for use as reducing agents for which purpose the zinc is not disadvantageous. Metallic calcium is a very active reducing agent, but is expensive and very difficult to make. Calcium-zinc alloys are easily made. "The alloys if containing even as much as 10 per cent zinc are brittle and easily powdered. These alloys promise to have a wide application as reducing agents in place of aluminium or pure calcium."

Extracting Potash from Feldspath.—A. S. Cushman, 851,922, April 30, 1907. Application filed Jan. 14, 1907.

The object is to extract potash, soda and other soluble bases from ground rocks. Feldspathic or other potash-bearing rock is ground to fine powder, slimed with water and placed inside of a wooden porous cup which is placed in a larger vessel filled with water. Electrodes are inserted in the inner and outer vessel, the electrode in the inner vessel being connected with the positive pole and that in the outer vessel with the negative pole. When current is passed through the cell the potash soda and other soluble bases are set free and pass through the wooden partition, so that the water in the outer vessel becomes alkaline. In order to accelerate the reaction which is otherwise very slow two methods may be used: (*a*) By a suitable grinding or churning arrangement the slime in the inner chamber can be kept in a continual agitation, which causes the necessary reactions to go on more rapidly. (*b*) If a small quantity of hydrofluoric acid is added to the slime a very great acceleration in the rate of decomposition and extraction is obtained, and it is possible in a reasonably short time to make a complete extraction of all the potash contained in a feldspathic rock. If instead of caustic potash it is desired to make various salts of potash such as are in ordinary use for fertilizers and other purposes, *i. e.*, nitrate, sulphate, chloride and phosphate, the corresponding acids, *i. e.*, nitric, sulphuric, hydrochloric and phosphoric, are fed in a dilute form into the outer chamber, fast enough to neutralizze the caustic alkali as it forms. By varying the amount of acid added the resistance of the cell can be controlled and the decomposition of the rock carried on under the best and most economic conditions. "This application is made under the act of March 3, 1883, Chapter 143 (22 Stat., 625), and the invention herein described and claimed may be used by the Government of the United States or any of its officers or employees in the prosecution of work for the United States, or by any person in the United States without the payment of any royalty thereon."

Removing Scale from Iron.—C. J. Reed, 855,667, June 4, 1907. Application filed June 18, 1906.

In the present method (see also page 220 of our June issue) the iron sheets, rods or wire from which the oxide scale is to be removed are made cathode in a strong sulphuric acid solution. The result is the reduction of the scale to a lower state of oxidation and its electrolytic solution with the production of ferrous sulphate. An insoluble anode is employed and sulphur or an oxidizable sulphur compound is supplied to the electrolyte, serving by its oxidation to both depolarize the anode and replenish the acid in solution. The following specific instructions as to carrying out the process are given. The electrolyte consists of an aqueous solution of sulphuric acid having a specific gravity of about 1.20 equivalent to an acid content of 27.1 per cent. The anode may be of lead and the current density at the cathode from 40 to 70 amps. per square foot. The electrolyte is preferably maintained at a temperature of about 60° C. Free sulphur or an oxidizable sulphur-bearing compound, such as a super-sulphide of a non-alkali metal, specifically pyrite, marcasite or pyrrhotite, is supplied to or maintained at or near the anode, and the sulphur is oxidized to trioxide at a rate corresponding to the reduction and solution of the scale on the cathode, thus continuously replenishing the electrolyte. A diaphragm cell may be employed to retain in proximity to the anode any sulphur dioxide resulting whereby it is finally oxidized to trioxide and prevented from interfering with the cathodic reduction. The production of sulphuric acid corresponds to the rate of its consumption by the formation of ferrous sulphate, the electrolyte thus being maintained at the proper concentration. In the case of a diaphragm cell, the concentration of the acid in the catholyte is maintained by diffusion and cataphoresis from the anolyte. As the amount of iron sulphate in solution approaches saturation the electrolyte or catholyte is transferred to a shallow pan and allowed to cool. It is preferable to reduce its temperature to about 0° C. by the use of a suitable refrigerant. The iron sulphate crystallizes out and the residual solution is returned to the electrolytic cell, no evaporation or further treatment being required to fit it for continued use as an electrolyte.

Electrolytic Tank.—J. F. Miller, 856,277, June 11, 1907. Application filed Feb. 6, 1906.

Details of construction of a tank or vessel for electrolytic work, especially for electrolytic refining. The chief features are indicated in the claim, which reads as follows: "A tank for electrolytic work comprising side walls built up of a plurality of longitudinal sections placed edge to edge and formed with registering vertical openings; tie rods passing through said openings; a bottom composed of longitudinal sections between the side walls and formed with aligning transverse openings; tie rods extending through said openings and projecting through the side walls; end walls located between said sides and abutting the same, and composed of transverse sections having vertical aligning openings and horizontal openings; a U-shaped stay-iron at each end of the tank; horizontal tie rods extending through the horizontal openings in the end sections, the ends of the side walls and the vertical portions of the stay-irons, and vertical tie rods extending through the vertical openings in the end sections, the bottom and the horizontal portions of the stay-irons."

Purifying Hydrocarbon Oils.—G. L. Neiburg, 856,361, June 11, 1907. Application filed May 25, 1906.

In a kerosene can, that end of the spout which is joined to the can is in communication with a tube with perforated walls and constructed of electropositive and electronegative metals so as to represent galvanic couples. When kerosene is to be poured out of the can the kerosene must first enter this tube through the perforated walls in order to get into the spout. In passing through the perforated walls it is sub-divided in a great many small streams and is simultaneously subjected to electrolytic action by the numerous galvanic couples. The effect is said to be the decomposition of any sulphuric acid, etc., contained in the kerosene, while simultaneously the perforated walls act as a filter and prevent any suspension from passing out of the can.

Electric Discharge.

Ozonizer.—H. N. Potter, 854,965, May 28, 1907. Application filed Jan. 6, 1904. (Assigned to George Westinghouse).

When an electric current is passed through a tube, made of a material which is pervious to ultraviolet rays (like silica), ozone is developed in large quantities. If, therefore, the tube of silica is provided with electrodes inside the tube, one of the electrodes being of some volatilizable material such as mercury and the other of iron or other solid material and an electric current is caused to pass through the space between the electrodes, ozone is developed in large quantities in the air outside of and about the tube. The inventor proposes to enclose such a tube within another tube which is impervious to ultraviolet rays; for instance, ordinary glass. If air is then passed from one end to the other end through the space between the outer and inner tube it is ozonized, and the ozone may be collected. Arrangements may be made so as to force the air to pass through a zig-zag or tortuous bath between the silica and glass tubes, whereby a higher degree of ozonization is procured.

SYNOPSIS OF PERIODICAL LITERATURE

A Summary of Articles Appearing in American and Foreign Periodicals

IRON AND STEEL.

Producer Gas.—At the Spring meeting of the Vereindeutscher Eisenhüttenleute, in Düsseldorf, May 12. J. Körting delivered a remarkable lecture upon "Gas Producers and Their Use in the Iron Industry," which is reproduced in full in *Stahl und Eisen*, of May 15, pages 685-713. Concerning the distillation of the fuel used in the producers, if fuels are distilled at a high temperature there result strongly illuminating gas and fluid tars; when the distillation takes place at a low temperature, as in a producer, the quantity of hydrocarbons given off is larger, the illuminating gases and hydrogen smaller, and the tar is viscous and pitchy—in the case of lignite and turf even paraffin may be evolved. The solid carbon is then gasified by the action of the producer proper. For complete production of CO gas the bed of fuel must be of sufficient thickness; for coke in pieces 3 x 2 centimeters, 0.75 meter, 3 x 5 c. m., 1.15 meter, 5 x 7 c. m., 1.8 meter; for anthracite 1 x 2 c. m., 0.55 meter is sufficient depth; with large lumps of anthracite 1.5 to 2 meters thickness is necessary. Using bituminous coals it is recommended to work the producer with a warm top, thus distilling the coal at a somewhat high temperature, and so decreasing the amount of heavy tar in the gas, and consequent loss of heating power by its deposition in the conduits.

Using steam with air, the gas is enriched in hydrogen, but, at the same time, always contains more CO^2; it should not exceed 3 to 4 per cent in a well-conducted producer. One kilogram, or steam to 1 kg. of carbon burned. is the limiting quantity of steam which can be used and properly decomposed. Methane, CH^4, is usually present, in quantities up to 3 per cent. Ethelyne (C^2H^4) and other heavy hydrocarbons are usually not present in more than traces, and then only when the coal gets distilled in the producer at a high temperature. If the products of distillation are forced to pass through the incandescent fuel. by the hopper-like arrangement of feed, the tar is split up, increasing the CO^2 and H^2 content of the gas and decreasing its CO. Free oxygen is seldom present in the gas; nitrogen varies from 60 per cent in dry running to about 50 per cent using steam. The calorific power of the gas varies from 900 to 1,100 Calories per cubic meter for simple gas, to 1,100 to 1,400 Calories for mixed gas. The gas possesses from 70 to 90 per cent of the calorific power of the coal from which it is made.

Körting next gives fifty-five analyses of producer practice, giving for each, in most cases, composition of the fuel, gas, calorific power of each, amount gasified per hour, temperature of gas. combustible in the ashes, useful effect of the producer. The fuel used contains up to 26 per cent ash, in some cases 30 up to 45 per cent water, calorific power 2,750 up to 6,780, gas up to 16 per cent CO^2, 11 to 31.5 CO, 0.2 to 4.05 CH^4, 3.0 to 19.6 H^2, 0 to 1.5 O^2, 42 to 61 N^2, calorific powers 960 to 1,542. combustible in coal 0 to 35 per cent, useful effect 56 to 81.9 per cent. The lecturer concluded with a description of all the various types of producers, old and new, with critical remarks on their weak and strong points. His figures on the efficiency of the Körting steam-air blower are instructive; with 8 atmospheres steam pressure, 25 grams of steam will deliver 1 cubic meter of air against 50 m. m. water-gauge pressure, 37 grams against 100 m. m. pressure, 55 grams against 200 m. m. and 74 grams against 300 m. m. water pressure.

Gas Volumes.—The determination of what volumes of hot gas are coming from a furnace, or being used in a boiler or gas engine, is an important matter which has not yet received a fraction of the attention which it deserves. Engineer E. Stach. of Bochum, discusses in *Stahl und Eisen* for May 1 the application of the Pitot tube to such purposes in a clear but not very convincing manner. The tube used has a flaring end to measure velocity head, and a similar end turned away from the current to measure static pressure. Since the shape of the latter causes a suction, this is corrected by calibrating the instrument in a current of air whose velocity is measured by an anemometer, and the error caused by the suction is assumed a constant proportion of the velocity head for all velocities. This method of correction is only approximate, however, and does not solve satisfactorily one of the chief defects of the Pitot tube. A registering apparatus devised by Paul de Bruyn, of Düsseldorf, is described, which records on a diagram the variations in velocity for a day or a week. Charts are given showing the variations in velocity in a down-corner from a blast furnace, and gas pipe from a coke oven, and the applicability of the apparatus to control the gas consumption of gas engines.

Hot Blast Stoves.—Fritz W. Lürmann, in *Stahl und Eisen* for April 10, makes a plea for two improvements in hot-blast stove practice. One is the use of refractory fillings which shall be at least as refractory as Seger cone No. 34, which is supposed to melt only at 1,870° C. Using such refractory brick the troubles of melting down the filling will be overcome, since the theoretical temperature of combustion of the gas lies between 1,425° and 1,880°, and is usually 60° to 100° less than this theoretical value, because of some excess air, about 10 per cent, being used for combustion. The other plea is for gas purified beyond the usual limit of 0.5 gram of dust per cubic meter. With this content of dust, particularly if it is of an alkaline nature or contains manganese oxide, the brickwork of the stove soon becomes slagged or fluxed, and the interior of steam boilers get a glassy or slag-like coating which is a very poor conductor of heat. In almost every case it will pay to purify the gases considerably beyond 0.5 gram of dust per cubic meter.

High-Speed Tool Steels.—In F. W. Taylor's address before the American Society of Mechanical Engineers the following classification of steels had been given: Carbon-chromium-tungsten; carbon-chromium-molybdenum; carbon-chromium-molybdenum-tungsten; carbon-tungsten-nickel. In a note from the author of the *Electrical Journal* of June it is pointed out that the investigations made by Mr. White and himself, and which included exhaustive tests on all of the above groups, showed the combination of carbon-tungsten-nickel to be unsuitable for high-speed tool steels, and, further, any combination in which nickel enters in or from which chromium has been omitted is equally unsuitable. The division of high-speed tool steels into the four classes given was a purely nominal one. and was based upon the outcome of a series of analyses made in 1904-1905 of twenty-two brands of commercial steel, both American and foreign, one of these being found to contain the combination of carbon-tungsten-nickel, as stated. Subsequent trials of this steel under actual shop conditions proved it to be inferior to most of the other samples in the amount of work performed.

COPPER.

Alloys with Silver and Lead.—K. Friedrich and A. Leroux, at the Bergakademie, Freiberg, are still adding to their metallurgical investigations. In *Metallurgie* for May 22 they publish a fine contribution of twenty-two pages, accompanied by forty-seven diagrams and thirty-four photomicrographs, dealing with the binary systems Cu — Ag and Cu — Pb. and the ternary system Cu — Pb — Ag. They found in the system Cu — Ag two kinds of crystals, one consisting of nearly pure copper, the other a solid solution of copper in silver. The eutectic contains 28 per cent of copper, melts at 778°, and exists nearly up to pure copper on one side and down to 6 per cent silver on the other. In the system Ag — Pb the eutectic is at 3 per cent silver, melting at 300°, and found in the alloys nearly to pure silver and to pure lead. In the system Cu — Pb there are two kinds of crystals of the pure or nearly pure metals, with no eutectic and no compound. In the ternary system Cu — Pb —

Ag, the ternary eutectic lies at 0.5 per cent copper, 2.0 per cent silver and 97.5 per cent lead, at about 299°. On one side of this point are mixed crystals of silver and copper containing very little lead, on another side crystals of silver with considerable lead and copper, on the third side nearly pure lead.

Alloys with Phosphorus.—E. Heyn and O. Bauer (*Metallurgie*, April 22 and May 8) have made a study of the alloys of copper with up to 15 per cent phosphorus. The melting point falls uniformly at the rate of 30° for each 1 per cent of phosphorus up to 6.5 per cent, then falls sharply to a eutectic containing 8.27 per cent of phosphorus, melting at 707°. Above this content the melting point rises rapidly to 1,018° at 14 per cent, and stays then practically constant to 1,022° at 15 per cent. The very well-marked eutectic was in evidence by arrests in the cooling curve at 707° for all the alloys from 2.76 to 14 per cent phosphorus. The electrical potential of these alloys against copper in normal $CuSO^4$ solution was measured. There was no difference of potential at all, *i. e.*, the alloy behaved like pure copper, until at 14.1 per cent phosphorus, corresponding to the formula Cu^3P, the potential fell to — 0.020 volt, and at 15 per cent phosphorus to — 0.063 volt. The conclusions from these observations as well as the microscopic tests are that up to 14.1 per cent phosphorus the alloys consist of mixtures of copper and Cu^3P, that higher alloys consist of mixed crystals of Cu^3P and another compound, probably Cu^4P^2. The specific gravities of the alloys fall regularly from 8.92 down to 7.18 at 14.1 per cent phosphorus (Cu^3P), and then more rapidly to 6.79 at 15 per cent. As for hardness, the eutectic at 8.27 per cent phosphorus was as hard as soft iron (0.05 per cent carbon), the compound Cu^3P was nearly as hard as hardened 0.95 per cent carbon tool steel. Alloys with over 14.1 per cent phosphorus lose their excess of phosphorus at 1,100° C., and come down to the compound Cu^3P. To make phosphor copper up to 20 per cent, copper filings are mixed with red phosphorus and the mixture put into crucibles, covering with charcoal. By heating to 300-400° C., not over 700°, a sintered mass containing up to 20 per cent phosphorus is obtainable, which can be used for the deoxidation of bronzes.

Gold.

Cyanide Practice with the Butters Filter.—Mr. E. S. Pettis, in *Mining and Scientific Press*, March 23, gives some data regarding the operation of the Butters filter at the Combination Mill, Goldfield, Nev. The plant in question contains two slime storage vats, two wash-water vats, the filter box and canvas frames, one acid box for washing the frames, one vacuum pump, one 4-inch centrifugal slime pump, one 2-inch centrifugal pump and the necessary valves and piping. The inside top measurements of the filter box are 9 feet 11¼ inches x 10 feet 2½ inches, the sides extending 5 feet 9½ inches above the cone. From the discharge gate to the top the distance is just 11 feet 7⅜ inches, the capacity is about 785 cubic feet when not containing the frames. The latter are 116⅛ inches x 56¼ inches, each having about 90 square feet of filtering surface. The frames are twenty-seven in number, namely, six sets of four and one of three. About 35 tons of slime are treated daily, forming a ¾-inch cake on the filters with a 22-inch vacuum. The washing is carried out with the same amount of vacuum for from 70 to 80 minutes with a weak solution of cyanide of 0.8 pound, about 10 tons of wash solution being used in that time. As the water is scarce in Southern Nevada, it cannot be used in the washing of the cakes, otherwise the time consumed would be about two-thirds of that required with the use of a cyanide solution. Less time would also be required for washing the cake if the slime could be agitated or heated in just twice as much solution as is used at present, thus necessitating less time of agitation. The time required for the various operations after the installation of the plant was as follows, the first figures referring to the minimum and the second to the maximum time required: Filling of box with pulp, 16-18 minutes; 22-inch vacuum, while forming ¾-inch cake, 19-22 minutes; employing box with 5-inch vacuum in cakes, 16-17 minutes; pumping in weak solution, 15-16 minutes; washing with weak solution, 15-inch vacuum, 40-50 minutes; pumping back weak solution, 15-16 minutes; filling with wash-water, 15-16 minutes; washing with wash-water, 22-inch vacuum, 30-50 minutes; sampling cake, 7-10 minutes; dropping cake with water, 12-14 minutes; running back surplus water, 8-10 minutes; sliming, 5-7 minutes; a total minimum time of 198, or maximum of 246 minutes. Five months later, with an increased amount of slime in the pulp and carbonate of lime formation noticeable on the filters, the time required was as follows: Filling, 18-20 minutes; vacuum, 22-25 minutes; emptying with 3-inch vacuum on cake, 17-20 minutes; pumping in wash, 16-18 minutes; washing with 22-inch vacuum, 70-80 minutes; sampling cake, 7-10 minutes; dropping cake, 14-15 minutes; running back water, 8-10 minutes; sliming, 5-7 minutes; total of 177 and 205 minutes, respectively. It was found that better results were obtained by giving only one wash. After the washing the cakes are dislodged from the frames by water forced from the inside. The formation of carbonate of lime on the filters is an essential obstacle which must be renewed. This cannot be accomplished by simply dipping the frames in a 2 per cent solution of hydrochloric acid, where any large amount of lime, from 7 to 20 pounds per ton, is used in the milling of the ore, but must be done by washing with the use of a vacuum or other means which forces the 2 per cent acid solution for 15 to 45 minutes through each cell of the cocoa matting. If the latter is done, the frames will only have to be cleaned once in three or four months, while the dipping would have to be done every three or four weeks. One man per shift operates the valves from a platform near the filter box, and he has plenty of time for other mill work. The author considers that as an improvement in mill work the Butters-Cassel process ranks with the tube mill.

Aluminium.

Progress in 1906.—In the *Engineering and Mining Journal*, of June 15, J. W. Richards reviews the progress in the use of aluminium in 1906. E. S. Sperry has studied the formation of pin-holes in aluminium castings. They are due to the metal absorbing gases while in the furnace and giving them out as it sets. To get absence of gas in the metal the top of the crucibles should project out of the fire and above the top of the furnace like a zinc melting pot. Overheating must in all cases be avoided. A. Brown recommends using chills at such parts of an aluminium casting as are ordinarily provided with risers. The latter are often a detriment to a fine casting, causing shrinkage cracks and being difficult to cut off. Pieces of sheet copper or brass, rather thick and flat, about 1/16 inch thick, may be used, being placed so as to cover the part of the casting which it is intended to chill into shape. They can thus be made to cause heavy portions of the casting to cool off as quickly as the lighter parts which are not chilled, and thus preserve the shape of the heavier parts, avoid unequal cooling and shrinkage strains. The proper heat for casting the aluminium is a very low red.

For electroplating upon aluminium, A. Giroux emphasizes the necessity of careful preliminary treatment. The articles are first cleaned in potassium cyanide solution until the greasy spots are loosened; then cleaned by brushing with powdered pumice until a clean surface is obtained. They are then to be well washed and dipped into caustic potash solution until gas bubbles are evolved, and are then immersed in cold water. They are then dipped into a solution containing 0.2 per cent of corrosive sublimate and 2 per cent of potassium cyanide. They are then dipped once into the caustic potash solution and placed at once in the plating bath. The plating must be done slowly and evenly, not at any time showing evolution of gas; only in this way can an adherent plating be obtained. (In connection with this subject the article by C. F. Burgess and Carl Hambuechen in our Vol. II., p. 85, contains useful, practical information on plating upon aluminium.)

Two new solders for aluminium are mentioned but it is stated that the one solder which has found most extended use in practice is that patented by Joseph Richards and containing 29 parts of tin, one of zinc, one of aluminium and one of phosphor tin. Reference is then made to the method of welding aluminium surfaces together and the progress which has been made by M. U. Schoop in this respect.

Concerning uses of aluminium it is said that aluminium is largely supplanting phosphide of copper as a deoxidizer in brass and bronze, in which it acts by reducing the oxides of copper, zinc or tin with which the metal may be contaminated. A small excess of aluminium does not injure the metal so much as a small excess of phosphor. Care must be taken, however, not to cast the alloy immediately after using the deoxidizer, since the alumina formed must be given an opportunity to rise out of the metal and enter the slag. With pure copper used for electrical purposes, silicon is found superior as a deoxidizer to aluminium, because the silica formed is less infusible, tends to unite with copper oxide to a fusible slag, and thus gets out of the melted metal quicker and more completely, leaving it with higher electric conductivity. Dr. Hans Goldschmidt, the inventor of the aluminothermic process, has recently patented improvements in his method of obtaining fluid iron at high temperature for welding purposes. In place of aluminium as the sole reducing agent acting upon iron oxide, producing the difficult fusible alumina, he uses a granulated alloy of calcium and aluminium, or a mixture of these two metals in granular form. This alloy gives a very high thermal effect, higher even than aluminium alone, while the heat of formation of the aluminate of lime slag is also utilized, and the slag is much more fusible than alumina alone. Supposing the alloy of calcium and aluminium to contain 42.5 per cent of calcium, corresponding to $CaAl_2$, the reaction on Fe_2O_3 would probably be

$$5Fe_2O_3 + 3CaAl_2 + 3(FeO.\ CaO.\ Al_2O_3) + 7Fe.$$

In this reaction 70 per cent of the iron in the oxide used would be reduced to the metallic state, while the resulting slag would be very fluid, and 1.4 parts of fluid iron at high temperature would be obtained per one part of calcium-aluminium alloy used. References are then made to the metallic paint of silver-white color made of powdered aluminium. Various miscellaneous applications of aluminium are dealt with, and finally notes are given on quite a number of aluminium alloys.

FUELS.

Charcoal Ovens.—E. Juon, of Nadeshdinski, Urals, describes in *Stahl und Eisen* for May 22, the improved ovens of Wladykin and Biynewitzch. These ovens are furnished with step grates, burn charcoal fines, and by tortuous flues distribute the heating gas very uniformly, so that variations of temperature of not over 35° C. occur in different parts of the furnace. In ordinary kilns variations of 130° in different parts are common, causing great variations in the carbon content of the charcoal, whereas, in these ovens the variations in carbon content are not over 2 to 3 per cent, making a very uniform quality. The plant at Bogoslow has forty-eight of these ovens, and the following observations and tests were made upon them: Immediately on charging wood and closing the oven, water comes off, and this period lasts 1 to 2 days, with temperature seldom exceeding 200° C. Then yellow vapors are given off, which condense to a brown fluid, this period lasting two to three days. The gas then becomes gradually colorless and "dry"; at this time hydrocarbons and hydrogen begin to come off plentifully. This lasts 3 to 8 hours, and then the chimney is shut off by a flue, all openings carefully luted, and the oven left standing. The gases still coming off cause an excess of pressure in the kiln, and the oven is let cool under this pressure until the sides are nearly cold. The duration of this cooling depends largely on the weather, lasting six to ten days, making the whole campaign ten to fifteen days.

The products of combustion from the combustion of the fines on the grate averaged over a long period (dried before analysis):

	Per Cent.
CO^2	16.8
O^2	0.1
CO	6.7
H^2	1.8
CH^4	0.2
N^2 (difference)	74.4

The uncondensed gases from the oven at different periods were carefully analyzed, and from them, on the basis of nitrogen content, the products coming from the grate were deducted, giving the real gases distilled from the wood and not condensed the following compositions:

	Temp.	CO^2	*CO*	H^2	CH^4
Beginning	< 170° C.	No uncondensable gas			
End of steam production	170-200°	68.3	29.6	trace	1.1
Beginning of first charring	200-300°	65.3	30.5	trace	3.9
Middle of first charring	300-370°	67.4	30.0	0.3	2.3
End of first charring	350-390°	43.4	26.7	2.8	26.2
Beginning of second period	390°	30.8	14.4	8.7	46.0
Middle of second period	150°	10.2	11.6	0.1	78.0
End of soaking period	60°	3.2	4.6	0.0	92.0

The cooling off period is characterized by absorption of CO, CO^2 and H^2 and great increase of hydrocarbons in the kiln. In this manner of working the charcoal contains 6 per cent higher carbon than when the oven is not sealed tight and put under its own self-generated pressure.

MISCELLANEOUS.

Calcium.—In *L'Eclairage Electrique* of May 25, Jean Escard gives a brief review of various processes for producing metallic calcium, especially by electrolysis, and also refers to calcium alloys. Metallic calcium is believed to be especially useful in metallurgy for purifying fused metallic baths on account of its reducing properties. Calcium hydride (trade name hydrolyte) in contact with water gives off pure hydrogen gas. One kg. of calcium hydride sets free 1 cubic meter of hydrogen.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Magnetic Manganese Steel.—Mr. R. A. Hadfield, of Sheffield, has recently patented (856,250, June 11, 1907) a composition of steel containing less than 1 per cent of carbon and from 10 to 40 per cent of manganese. This steel has certain distinct properties which are not found in high-manganese steels as heretofore made, due to the fact that formerly ferro-manganese has been used containing too high a percentage of carbon, say, from 6 to 9 per cent. If ferro-manganese is used, however, as made in the electric furnace, with a low content of carbon, say, from 2 to 3 per cent, and containing from 70 to 90 per cent of manganese, the resulting steel has very distinct properties. Owing to the comparatively low percentage of carbon in the manganese steel, the steel is rendered much less liable to fracture during the cooling, or heating and cooling treatment for toughening it, and such steel is distinguished by its relatively strong magnetic character. In making the steel the ferro-manganese is added, preferably in a molten condition, to a base of molten decarbonized iron, such as that used in the production of acid steel, and from which practically the whole of the carbon, silicon and manganese have been eliminated in suitable manner, as, for instance, by the pneumatic or the open-hearth method.

Flux for Soldering Cast Iron.—Owing to the impurities of carbon, silicon, etc., cast iron has proven difficult to solder or braze without the employment of oxidizing fluxes. Certain of these now in use contain heavy metallic oxides which are

intended to remove the impurities by selective oxidation and form a sort of wrought iron surface to which the solder or spelter will adhere. According to Carleton Ellis (852,017, April 30) such fluxes require a high temperature to complete the operation. He has found that a lower temperature is quite sufficient if the flux contains, as an essential element, chemically pure and finely divided iron. Another element is anhydrous borax or other easily fusible, non-oxidizing anhydrous salt or compound. The action of a flux of this character, viz.: pure iron and anhydrous borax, is to remove the impurities from the cast iron surfaces to be joined, by a sort of impregnation. In other words, the chemically pure iron at a low red heat is most avidious for carbon. silica, etc., and absorbs them from the cast iron surfaces with great rapidity. Thereby the surfaces are purified and put into condition for uniting with the solder or spelter which is subsequently introduced. To produce the finely divided chemically pure iron, oxalate of iron is ignited in a current of hydrogen. "A suitable composition for general purposes may be obtained by mixing thoroughly the following: Fused borax (pulverized), 12 pounds; iron powder, C. P., 40 pounds; carbonate of potash, C. P., 9 pounds." A quantity of this mixture is worked up with water to a thick paste and is applied to the cold cast iron surfaces to be joined. The surfaces are then pressed into contact and are heated by a gas flame or otherwise. When the brazing temperature is reached the solder is run in together with copious additions of anhydrous borax until union is complete, when the object is carefully cooled and cleaned. During the stage of cooling the pieces of cast iron should be kept in immovable contact. "In this manner iron castings of every description may be easily and firmly joined."

Alloys.

Purifying and Alloying Metals.—In a patent of I. L. Roberts (845,819, March 5, 1907) a method is described "of varying the composition of a metallic alloy or mixture, which consists in treating the same in the molten state with a flux composed of fluorides and containing a compound of a metal less basic than the element to be removed from the alloy or mixture." The method may best be explained by some examples. Raw or crude copper frequently contains iron. To remove this the copper is melted and a flux consisting of a mixture of calcium and sodium fluorides with a sufficient quantity of copper fluoride is added and the whole agitated. The fluorine has a greater affinity for iron than for copper, hence the copper in the copper fluoride contained in the flux is released and the iron from the crude copper takes its place. Zinc, cadmium and any other metal for which fluorine has a stronger affinity than for copper, may be removed in the same way. A second example is the manufacture of nickel steel. By melting together cast iron with a flux of calcium and sodium fluorides containing an oxide of nickel, such substances in the iron as carbon, sulphur, phosphorus, arsenic, etc., will be oxidized by the oxygen from the nickel oxide and will be taken up by the flux. while the metallic nickel thus freed will alloy with the iron. In the same way chromium may be substituted for other substances in the iron and chrome steel may be produced, etc. A third example is the removal of sodium from an aluminium-sodium alloy. By using a flux of calcium and sodium fluorides the fluorine in the aluminium fluoride will take up the sodium from the aluminium-sodium alloy, releasing the aluminium with which it was in combination. Or if fluoride of magnesium is used to remove the sodium the product will be an alloy of aluminium and magnesium, which is known under the name of magnalium.

Tin.

Detinning.—We have repeatedly referred in these columns to the important industry of recovering tin from "tin scrap." This scrap comes from the factories making tinned iron cans, etc., which are now used to such an enormous extent. The detinning industry is at present undergoing changes in two different directions. First, with respect to the material treated the scrap of the can factories, *i. e.*, quite a clean and pure raw material, iron covered with tin, was formerly exclusively used, while according to a patent recently noticed in this department, at least one plant, namely, the pioneer plant of the whole industry, that of Theodor Goldschmidt, in Essen, now also recovers tin from cans which have been in use. Here the raw material is exceedingly impure, but if success is attained the sphere of the process is immensely broadened. The second important change is the method of working. In the past the process of detinning has been electrolytic, while now detinning by means of chlorine is pushing to the front. To emphasize this change still more the electrolytic detinning process has always been treated as a secret process, not protected by patents and, of course, never adequately described in print. On the other hand, with respect to the new chlorine-detinning process there exist already quite a number of patents. Several important patents of Dr. Karl Goldschmidt have been discussed before in these columns. In the following we record four more patents granted to American inventors.

Messrs. F. von Kuegelen and G. O. Seward (851,946, April 30) refer to a former process patented by them, in which the scrap is placed in a vessel and dry chlorine is admitted thereto, attacking the tin and forming stannic chloride, which is condensed upon the walls of the vessel. The temperature must be carefully controlled. It must always be kept below the point at which iron-chloride is formed. If, however, to avoid this result the temperature is kept too low, the detinning is slow and not so complete as it should be. To prevent overheating the inventors formerly proposed to limit the amount of chlorine introduced and at the same time to cool the vessel externally. In the present patent they propose to obtain the same result by limiting the amount of tin scrap placed in the vessel. "It is impossible to lay down any definite limits of proportion for the successful practice of our invention, but with a chamber of 40 cubic feet capacity, a charge of 150 pounds of tin scrap has given successful results."

Another method is this: "Instead of limiting the amount of chlorine or amount of scrap used in a vessel of a given size, we use at once such a powerful current of chlorine that the same is present in great excess above the reactive proportion. Chlorine is now passed through in such a large volume that the current of cool gas flowing through the detinning tank exerts a cooling action on the contents."

A second patent of the same inventors (853,461, May 14) refers to the method of removing the stannic chloride formed from the vessel in which the process has been carried out. "After the reaction is complete and the tin in the tank has all been converted into stannic chloride which has been removed as much as possible by gravity from the bottom of the tank, we continue to pass dry chlorine through the tank, which now contains scrap free from metallic tin, but with a certain amount of stannic chloride adhering to it. Chlorine has the capacity of absorbing a great quantity of stannic chloride, and by availing of this property we thus get rid of the remainder of the stannic chloride so that it is taken up by the chlorine and passes out of the tank with it. The operation might be likened to the drying of a damp vessel by passing dry air through it."

Mr. Charles E. Acker (855,491, June 4) patents a "process of detinning which consists in subjecting compressed tin scrap to the action of a detinning reagent, and forcing the reagent into the interstices of the scrap by varying the pressure during the detinning." The detinning reagent may be an "elementary gas or gas mixture, for example, chlorine, bromine, or a mixture of either of these gases with other gases or air; a solution of an elementary gas in a liquid. for example, chlorine in carbon tetrachloride or stannic chloride; or a gaseous or liquid compound, for example, a chlorine compound in which the chlorine is loosely bound, such as bromine chloride."

A second patent of the same inventor (856,753, June 11) relates to the treatment of the detinned iron and residues which remain after the tin-plate scrap has been subjected to

the action of chlorine, converting the tin into its chloride. The residual mass, on account of its numerous interstices, retains a considerable percentage of the tin salt. To recover it the detinned material is washed with an anhydrous liquid, which is a solvent for stannic chloride, specifically with carbon tetrachloride, or anhydrous petroleum. The wash liquid, containing the dissolved chloride and usually some chlorine, is then run off and may be used for the treatment of other residues. After it is drained off the portion adhering to the residue may be removed by a current of air by means of an exhaust pump. The mixed air and vapor is then passed through a solvent for the vapor, preferably a heavy mineral oil. "The detinned iron resulting from the treatment of scrap with chlorine is usually coated in part with a very thin film of ferric chloride. In order to remove this film and protect the surfaces from rusting upon exposure to the atmosphere, it is desirable to submerge the metal, either before or after removal from the detinning chamber, in a weak alkaline bath, for example, an aqueous solution of sodium hydroxide or carbonate."

Neutral Soldering Flux.—O. J. Lanigan (851,813, April 30, 1907) describes the composition of a neutral flux specially suitable for soldering the seams or caps of tin cans. The flux consists of equal proportions of glycerine and ammonium lactate. The flux, being neither acidulous nor alkaline, does not deleteriously affect canned fruit products.

ALUMINIUM.

Alloy.—A. Chambaud (856,392, June 11, 1907) patents a new aluminium alloy for which very characteristic qualities are claimed. It consists of 99.020 per cent aluminium, 0.310 iron, 0.010 zinc, 0.041 magnesium and 0.610 copper. To manufacture this alloy about 20 per cent of the aluminium to be employed are first melted, and when the temperature has reached about 750° C. copper is added, and when the fusion of this last metal is complete zinc is added and afterward iron, and when the fusion of the mixture is complete the remaining 80 per cent of aluminium are added. Finally, the magnesium is incorporated when the fluid mass is withdrawn from the fire. The alloy is of a white silvery color and has a density not exceeding 2.7. It is claimed to be very elastic, malleable and ductile and more tenacious than copper, to beat out, emboss, hammer, bend, wire draw and weld very easily. It can be worked without the use of special tools. It is said to have great tensile strength and not to be oxidizable in air or water. It is stated to be particularly useful in cases where it is exposed to the action of sea water. It is said not to be seriously attacked by any acid except hydrochloric acid.

A Proposed Society of Chemical Engineers.

A meeting of those chemists who were in favor of the establishment of a Society of Chemical Engineers, and who were in attendance at the American Society for Testing Materials, was held at the Hotel Chalfonte, Atlantic City, Friday, June 21, at 5 P. M. The meeting was called to order by Mr. Richard K. Meade. Dr. Charles F. McKenna was made chairman and Mr. William M. Booth, secretary.

Mr. Meade then stated that he had issued a call for the meeting because of the numerous requests which had been made that he should take the initiative in the organization of such a society. He further stated that he had been informed that a society of chemical engineers was in process of organization on the Pacific Coast, and he had been urged to make the movement a national one. Mr. Meade said he felt that such a society was really needed, and had sounded the profession by some fifty or more letters of inquiry to prominent technical chemists and engineers.

A large number of those approached replied, expressing their opinions quite freely, and for the most part were in favor of the organization of such a society to be known as the American Society of Chemical Engineers. Those in favor of the organization thought it should have a high standard of admission, somewhat along the requirements of the American Society of Civil Engineers, and that it would prove of great benefit to all qualified technical chemists. For the members of the new society it was suggested that it might, by the appointment of committees, solve many problems of engineering chemistry, widen the field of applied chemistry to the point where chemical plants will be designed as far as the chemical features go by chemical engineers; further the interests of the consulting chemist by the discouragement of unprofessional methods, and if possible cause the elimination of all incompetent and dishonest followers; the direction of the education of technical chemists along lines most likely to be of benefit to the industries of the country, for the commingling of the ideas of professional men with those of teachers of applied chemistry; the unification of the methods of technical analysis by committees which should represent both manufacturers and users; the encouragement of patent legislation which will give the greatest security to the inventor of chemical processes and appliances for carrying them out, etc.

The discussion naturally turned first to what the term "chemical engineer" really means. This was answered provisionally by Mr. Booth as follows: Chemists or mechanical engineers who design and construct plants of a nature requiring a thorough fundamental knowledge of applied chemistry may be termed chemical engineers.

The various difficulties in the way of forming a society of chemical engineers were gone into at great length. Those who took part in the discussion were Prof. H. B. Talbot, Mr. H. E. Diller, Mr. E. C. Holton, Prof. J. C. Olsen, Prof. William H. Walker, Dr. J. E. Stokes, Mr. Andrew Robertson, Mr. A. D. Little and Mr. Richard K. Meade. Finally, it was decided upon motion of Prof. Olsen to appoint a committee of five men with power to consider the advisability of organizing a society of chemical engineers, that this committee correspond with men likely to be interested, and, further, that the conditions of membership of such a society be formulated. Dr. McKenna named the following: Prof. J. C. Olsen, Mr. A. D. Little, Mr. Richard K. Meade, Prof. Wm. H. Walker, Mr. William M. Booth. Mr. Olsen offered a motion that Dr. McKenna act as chairman of this committee, thus increasing the number to six. This motion was carried.

It is expected that a report will be made sometime during the summer.

Repairing with Thermit.

The chief difficulty in doing general repair work by the thermit process has been to design the proper pattern for the mold, and to determine the correct amount of thermit to be used. This has usually necessitated dividing the work between the foundry and the forge shop, and has often been the cause of delay and trouble.

The Goldschmidt Thermit Co. has now developed a system which obviates these difficulties and permits of the entire work being done without the aid of the pattern maker.

By this system yellow wax is used as a pattern or matrix for the casting, and the parts to be welded are simply laid together, and this yellow wax pattern shaped about them. After this is done the mold box is placed in position, and molding sand (consisting of a mixture of fire-clay and sand) tamped around the matrix in the usual manner, except that a small hole is left in the lowest part of the mold. The pattern for gate and riser may be easily constructed of wood in the usual manner. After the mold box is completely filled the gate and riser patterns are withdrawn, and a torch applied through the riser to the wax matrix, which will melt and run out through the opening at the bottom. The heating should be continued until the metal is

red hot and the mold thoroughly dry, after which the opening at the bottom should be closed with a sand core. The weight of wax should be multiplied by 32, to give the correct weight of thermit required for the weld. For welds requiring over 50 pounds of thermit 15 per cent of punchings should be used, for smaller welds 10 per cent of punchings. The pouring is performed in the regular way.

This system of wax patterns enables repairs to be made much more quickly, cheaply and accurately than heretofore, and is applicable to all kinds of thermit welds.

For the special problem of welding locomotive frames the Goldschmidt Thermit Co. has recently perfected a mold made of fire-brick which can be obtained in standard sizes ready for use; this eliminates much of the preliminary work which was formerly necessary and allows of the repair being made quickly and accurately. The work can now be done in division shops and round-houses, as all tools necessary are part of equipment of such shops. Further details may be found in a pamphlet recently issued by the Goldschmidt Thermit Co. on fire-brick molds for welding locomotive frames by the thermit process.

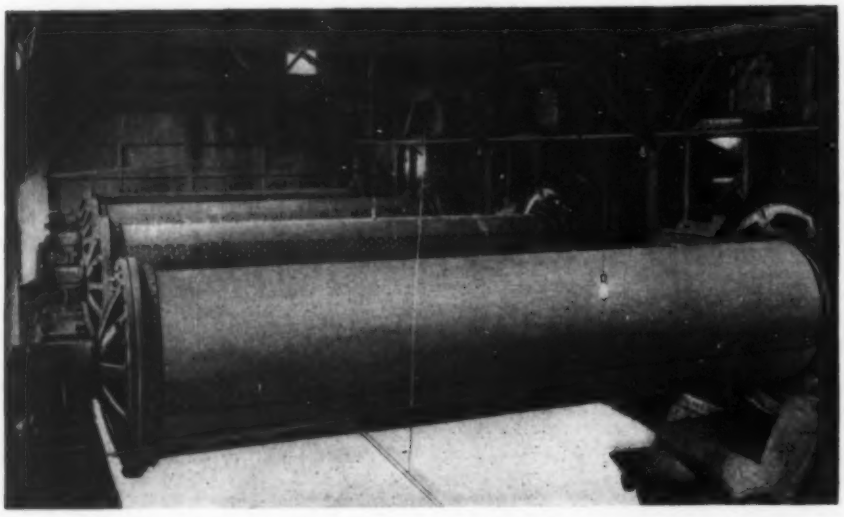


FIG. 1.—SET OF FOUR TUBE MILLS.

Large Tube Mills in the Cyanide Process.

In view of the interest that is now being taken in the cyanidation of gold and silver ores, where the question of a fine pulverizer or slimer is one of vast importance, it might be interesting to consider some of the features of one of the largest tube-mill installations made in connection with this class of work.

The United States Reduction & Refining Co. purchased in the early part of 1906 one of the usual style trunnion tube mills, 5 feet diameter by 14 feet long, for the purpose of making experiments on fine grinding and studying the obtainable extraction on the tailings accumulated at their mills at Colorado City.

The machine installed had the usual trunnion type feed equipped with stuffing box, etc., had manholes in the shell, so that the mill could be relined, fresh pebbles put in when necessary, and all the usual troubles were experienced, to wit: There was a constant tinkering with the feed on account of leakage and the lining kept on falling out around the manhole opening. Notwithstanding these facts the users became convinced that the process would be advantageous to them so that they took up the matter of a larger plant.

They had presented for their consideration the Abbé tube mill, and although they were first skeptical in reference to the advantages of the "ideal" spiral feed and discharge, with which this tube mill is equipped (described and illustrated in our Vol. III., p. 42), they decided to try an experiment on their own account. A rough spiral of pipe was built and attached to the trunnion of the tube mill which they had, with the result that this proved to be entirely satisfactory to them in every respect, so that they placed their order for eight Abbé tube mills, 5 feet diameter by 23 feet long, the order being placed at several thousand dollars higher than the nearest competitor's figure.

These machines are without doubt the heaviest ever constructed for mining work, the iron and steel work alone weighing 38,000 pounds for each mill. This is without silex lining or pebbles.

In view of the fact that the United States Reduction & Refining Co. had operated another make of tube mill at their plant, they installed for each two machines a separate 150-hp. motor, as they did not take into consideration that with the use of the spiral feed they would gain the additional advantage of reducing the horsepower on account of being able to load the mills over the center with pebbles.

Recent tests made by Mr. Fox, superintendent of the plant, show that each mill only requires 46 hp., or somewhat more than one-half what was allowed to operate them. The trunnion bearings of the mills were made very large and were equipped with water-cooling boxes. The material being reduced by the machines is known as chlorination tailings and passed through a 12-mesh screen. The finished product delivered is 100-mesh.

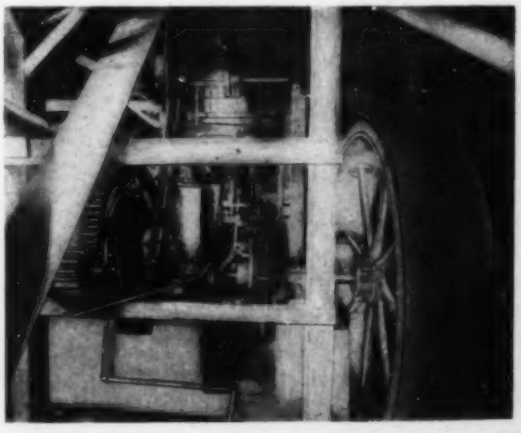


FIG. 2.—DRIVE OF TUBE MILLS.

The capacity of the machine is 160 tons each per 24 hours, which is certainly an remarkably high output for a machine of this size.

Fig. 1 shows the discharge ends of four of the tube mills, being one-half of the plant. These machines, as shown in Fig. 2, are driven by very large wood-split pulleys, which are belted direct to the motors.

Another feature of the plant worth while mentioning is that the tube mills, instead of having a spiral feed inside the mill, have the same attached on the outside to the trunnion. This

is an entirely new construction, and has proven itself to be just as satisfactory as the older method. The application is covered by numerous patents granted to Mr. Max F. Abbé, president of the Abbé Engineering Co.

Among the advantages of the "ideal" spiral feed are the following: It does not require a separate drive; it has no stuffing boxes; it does not wear out, get clogged up or break; it can be used for feeding the pebbles into the mill and the spiral discharge is used for discharging them, thus avoiding all labor of shoveling; it enables the loading of the mills with pebbles over the center, thereby decreasing the horse-power and increasing the capacity.

In wet grinding the machines are pumped two-thirds or three-fourths full, thereby practically doubling the grinding capacity and decreasing the horse-power still more.

Multimeter and Electroplaters' Voltmeter.

The Weston Electrical Instrument Co., of Waverly Park, Newark, N. J., have recently placed on the market two new instruments which have the advantage that each may replace a number of other instruments, thus permitting a considerable saving in the first cost of installation.

The Weston multimeter which is shown in Fig. 1, has its name derived from the fact that it may be used for an exceptionally large number of different measurements, since it will quite accurately serve the purposes of a direct-current voltmeter, milli-voltmeter, ammeter, mil-ammeter, ohmmeter, ground detector and wheatstone bridge. At the same time a much higher degree of accuracy is obtainable with it than with any so-called "universal instrument."

The multimeter consists of a Weston type wheatstone bridge, a battery of twelve silver chloride cells and an indicating instrument with detachable shunts.

The calibrated scale of the instrument has 160 divisions, with the zero placed at ten divisions from the end, so that when the instrument is used as a galvanometer in connection with the bridge, both positive and negative deflections may be observed.

FIG. 1.—MULTIMETER.

The shunts are fastened in a compact form to a single base. They have binding screws, and can easily be connected to the instrument by flexible cables about 6 feet in length, furnished with the instrument for that purpose. The shunts are constructed of Weston patent alloy having a negligible temperature coefficient, so that the combination of instrument and shunt is practically free from errors due to changes in temperature.

The wheatstone bridge, which forms a part of the multimeter, consists of a rheostat with three groups of coils, adjusted respectively to units, tens and hundreds, aggregating 999 ohms, and a set of five ratio coils. Many novel features are embodied in its construction, and its design is such that compactness and durability are combined with convenience of arrangement, and an exceptionally high insulation resistance. All conductors and plug receptacles are placed under, instead of upon, the rubber top. This form of construction prevents any reduction in the insulation resistance, as the under side of the rubber plate is not exposed to the deteriorating effects of light, dirt and moisture.

The large area of conductors employed, their compact arrangement and the absence of all temporary imperfect connections, together with the perfect fit of the five plugs, which are all that are required, make the "zero" resistance of the instrument less than that of any other portable bridge.

A push button is the only visible part of the double successive contact key, by means of which the galvanometer and battery circuits are made and broken.

A separate compartment in the case is provided for the battery, which consists of twelve cells connected together in series and fastened to a hard rubber top. A single cell may be used,

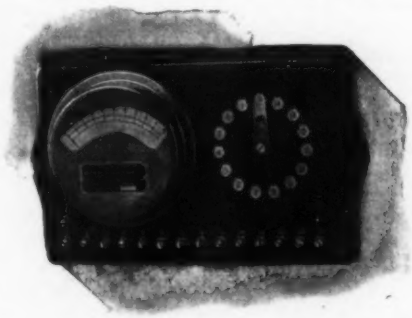


FIG. 2.—ELECTROPLATERS' VOLTMETER.

or several in series. Any cell may easily be removed in case of necessity. Exhausted cells should be taken out, and if not replaced by others the terminals to which they are connected should be short circuited.

The second new instrument of the Weston Electrical Instrument Co. which we wish to describe in this article is a special voltmeter for electroplaters' use, and is shown in Fig. 2. Its special feature is that it may be used for measuring the voltage on any one of a number of plating tanks in an establishment up to fourteen. In other words, this instrument obviates the necessity of having a separate voltmeter for each tank and enables the plater to avail himself of an extremely accurate and reliable instrument at a very low cost. It has long been perfectly well understood that it is of utmost economy to control the electric current during the plating process carefully with the aid of measuring instruments, but the initial cost of installing an instrument for each of the plating tanks has been a great drawback. This drawback is now completely overcome.

The feature of the instrument is its combination, in one case, with a switch which permits, by simply turning a lever, to connect the instrument with any one of fourteen different circuits. Each of these circuits is, of course, connected with a different plating bath. In Fig. 2 the terminals of the fourteen different circuits are indicated by corresponding figures. It will be evident that the application of the instrument is exceedingly simple, since when the connections have once been made it is only necessary to turn the lever of the switch on the left-hand of Fig. 2 to the number of the tank to be tested and take a reading of the instrument.

A New Portable Combination Meter.

The unique combination of a voltmeter, ammeter, wattmeter and horsepower-meter in one instrument is accomplished in the "Victor" combination meter for direct current, manufactured by the H. W. Johns-Manville Co. This instrument was first placed on the market somewhat over a year ago, and was first designed for switchboard use in central stations. The success of the instrument for this purpose has recently lead to the placing on the market of a portable form for general electrical testing, an illustration of which appears herewith.

The "Victor" meter consists of two separate and complete instruments in a single case, the one giving readings in volts and the other in amperes. The third and fourth readings are obtained on a scale plotted at the center of the dial, giving the product, or power consumption, in watts or kilowatts and horsepower. These readings are taken at the points of intersection of the two indicators. The power scale is calibrated in "watts" or "kilowatts" on one side and "horsepower" on the other.

COMBINATION METER.

The convenience in having in one instrument a portable meter giving readings in volts, amperes, watts and horsepower is readily appreciated at a glance, as this meter is adapted for rapid testing in the laboratory as well as for field work.

If desired, multiple shunts and extra multipliers are furnished in connection with the volt and ampere scales for additional readings, and a table, containing the multiplying factor to be used with these various combinations when reading the central scale.

The Welding of Copper, Brass and Bronze by the Epurite Process.

The principal application of the epurite autogenous welding process is in the welding of iron and steel, as was described in the article of Mr. A. Beltzer on page 284 of our Vol. IV., but it is used now also for the welding of copper, brass and bronze, and it offers great advantages in this field.

The working of copper is especially interesting in piping. Heretofore copper piping has been brazed and is not always resistant. Numerous explosions have been caused by the slow destruction of the brazing under the influence of the voltaic elements formed by the presence of zinc and copper. The zinc is dissolved gradually by the inorganic acids from the impurities of the water and by the organic acids of oils which may obtain in the piping. The brazing is transformed into a copper sponge, absolutely non-resistant. With an autogenous weld, however, this defect disappears entirely.

In welding copper wire the tensile strength at the joint is never greater than two-thirds of the original tensile strength, and it is interesting to note that the wire breaks near the weld, but never at the weld itself. The reason of diminished strength is that the heat of the blow-pipe is concentrated on one part of the metal without being conducted away through the wire, copper becoming less resistant under the action of the heat.

Brass can be welded by using borax as a flux.

The epurite welding process can also be used with great advantage in repairing bronze and brass castings. The amount of money saved in repairing bronze castings is quite an item, as these castings are generally very costly. The cracks or flaws are first well cleaned, and when the metal begins to melt the holes are filled up by holding a bronze wire in the flame.

When two large surfaces of metal are to be joined together this is done by brazing with the blow-pipe. Sometimes it is better to braze copper than to weld it where the metal has to support elongation and bending, losing as it does some of its resistance near the welded point on account of the heat applied. The small dimensions of the oxy-acetylene flame allows the use of a brass wire, instead of the ordinary method, which can be melted with great accuracy into the joint to be filled. These brazings are clean and quickly made.

Autogenous Welding With the Oxy-acetylene Blow Pipe

In the preceding note we referred to the very interesting article by Mr. André Beltzer on the autogenous welding of iron by the oxy-acetylene blow-pipe and a new method of generating oxygen. The system described is that of the Industrial Oxygen Co., of New York City. The oxygen is obtained from epurite in contact with water, the acetylene from calcium carbide in contact with water. The arrangement of the apparatus as well as the principles of the oxy-acetylene flame were fully described by Mr. Beltzer.

A plant for autogenous welding by means of this process has recently been installed by the Worcester Pressed Steel Co. at Worcester, Mass. This is the second plant in this country, and the results which this company have obtained with the process in commercial operation should be of interest.

It has been established in practice that this process is valuable for replacing riveting and brazing in many instances. Two sheets of metal may be welded by placing their edges in contact and following along the seam with a blow-pipe. Practically seamless steel and copper tanks of almost any shape and size may be made by forming the body and ends separately and

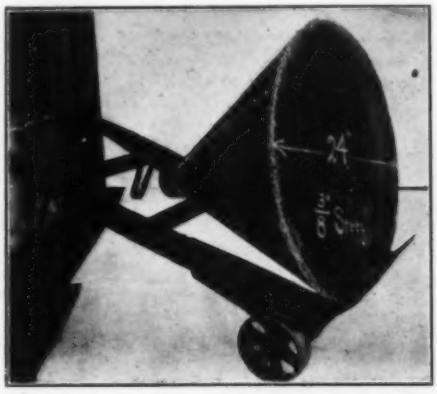


FIG. I.—WELDED STEEL TANK.

tracing the seams—joints butt and flush—with a blow-pipe. Many designs and forms, not otherwise possible to construct, are made practicable and feasible by this process.

This autogenous welding process is especially valuable in the foundry, as the blow-holes and similar defects in castings and forgings are made good. Cast iron, wrought iron, steel castings and forgings, copper, brass, bronze and aluminium in many forms of construction are effectively welded either in the manufacture of new parts or in repairing accidental breaks.

To insure strength, the joint is slightly overloaded by melting a wire or rod of same material as metal to be welded at the same time the edges are fused. The unfinished joint is stronger than the body of the metal and the finished joint is practically the same.

Any shaped hole can be easily cut in steel plates up to 6 inches in thickness, as with the blow-pipe the operator can accomplish cutting feats impossible with a saw. In cutting, the flame is proportionately elongated by pressure to penetrate to the bottom of the cut. The intense heat is so localized that the kerf is practically the same as if a saw were used.

No flux or moulds are required to weld metals such as iron, steel and copper, but for alloys, viz.: brass, bronze, etc., a little borax or boracic acid moistened with water is used simply to prevent the volatilized zinc from being deposited on the joint and destroying the weld. This process welds by fusion, forming a perfect metallic union of the parts which is imperceptible after finishing. It is not brazing.

It has been found that an operator of average ability can

weld steel or copper sheets at the rate and cost for gas approximately as follows:

	Per Inch.
.035″ (about 1/32″) 288″ per hour	$0.0031
.062″ (about 1/16″) 200″ per hour	.0065
.125″ (about 1/8″) 120″ per hour	.016
.377″ (about 3/8″) 60″ per hour	.075

Metals ¼ inch and less in thickness can ordinarily be welded cheaper than riveted. Steel and copper tanks for high and low pressure of almost any dimensions are effectively welded in place of riveting; broken steel shafts and other forgings repaired, cast iron welded, with copper or steel and blow-holes and similar defects in castings and forgings made good. The two adjoining illustrations show results obtained with the process, Fig. 1 representing a welded steel tank and Fig. 2 welded forged steel crank shafts.

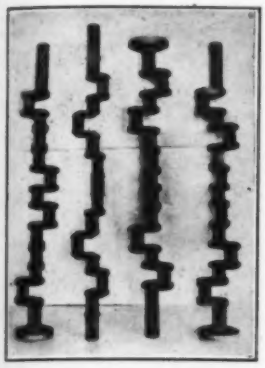


FIG. 2.—WELDED FORGED STEEL CRANK SHAFTS.

The Worcester Pressed Steel Co. have accomplished some difficult autogenous welding with aluminium, practically overcoming the trouble from the oxide which forms on the surface of aluminium when exposed to the atmosphere. Although aluminium melts at a comparatively low temperature (1,200° F.) it rapidly conducts and absorbs heat and requires a comparatively high local heat to obtain the best results.

Fertilizers from Atmospheric Nitrogen in America.

In view of the immense importance of the fertilizer problem, the utilization of nitrogen from the atmosphere for the production of nitrogen-containing fertilizers has been one of the most attractive propositions of electrochemistry. This problem has been attacked from quite different points of view. One line of work tends to use electric discharges through air to combine the nitrogen and oxygen contained in the air and subsequently to produce nitrates. The most noteworthy [illegible] researches carried out in this direction in this country has been the work of the Atmospheric Products Co. in Niagara Falls, under the patents and direction of Messrs. Bradley and Lovejoy. Though carried out on a comparatively large experimental scale it has not resulted in the establishment of a permanent industry, and the plant at Niagara Falls has been given up. Greater success has accompanied the work of Birkeland and Eyde in Norway, who are operating their process on a commercial scale.

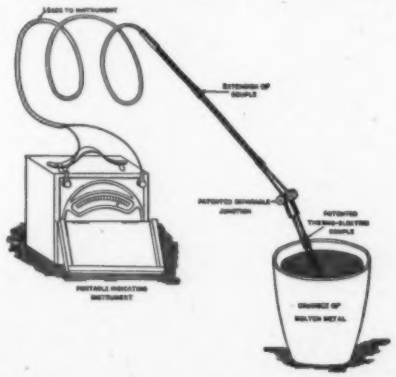
A second way of utilizing the atmospheric nitrogen for fertilizers is to start with calcium carbide as produced in the electric furnace and treat it at an elevated temperature with nitrogen which has been previously isolated from atmospheric air. The result is calcium cyanamide, or as the Germans call it, Kalkstickstoff (lime-nitrogen), the process being that of Frank and Caro. We have reported at length on developments in this direction in the past and may refer especially to the paper of Dr. Erlwein on page 77 of our present volume.

After the success which this process has achieved in Europe, the American Cyanamid Co., which was recently formed in this country, with headquarters at 100 Broadway, New York City, intends now to erect an initial plant of 20,000 metric tons annual capacity at Muscle Shoals, on the Tennessee River, in Northern Alabama. The reasons for selecting this location are given in a recent statement of the company as follows: "Here contiguous to the great Birmingham coal and iron district is cheap water power, the cheapest coke in the United States, limestone of unsurpassed quality and cheapness, and abundant and efficient labor. The advantages of this situation are unusual in respect to the facts; first, that the Tennessee River is one of the network of great interior navigable rivers of the Mississippi Basin, reaching the greatest agricultural regions of the country; second, that two great railway systems are available for reaching every market; third, Muscle Shoals is on the border of the great phosphate of lime deposits of Tennessee, with the acid product of which lime-nitrogen will be mixed universally in making the standard commercial complete fertilizers; and, fourth, the factory will be in the heart of the great cotton growing region of the United States, and close not only to the hundreds of fertilizer factories scattered throughout that section, but also to those which have clustered about the phosphate deposits."

As stated in Dr. Erlwein's paper referred to before cyanamide may also be used as a starting material for the production of sodium and potassium cyanide which are in such extended use in gold and silver metallurgy. The erection of a cyanamide factory in Mexico solely for this purpose is stated to be now under consideration.

A Portable Pyrometer for Instantaneously Taking Temperature of Molten Metals.

In manufacturing processes and in metallurgical work molten metals and alloys are extensively employed, especially for the making of castings from moulds, and it is of the utmost importance that the metals be mixed, alloyed and poured at the proper temperatures in order to obtain the best results. The special form of pyrometer described here has been designed to meet the practical requirements of everyday shop practice. The portable indicating instrument may be carried in the hand, and within two or three seconds the temperature of the molten



PYROMETER FOR MEASURING TEMPERATURE OF MOLTEN METALS.

metal may be taken. The possibilities and great value of an instrument of this kind will be fully appreciated by those who are interested in foundry work of any description.

The outfit complete consists of a portable indicating instrument connected to a special thermoelectric couple, the two elements of which are disconnected and left without insulation. When the tips of these elements are slightly immersed into the molten metal an electric connection is made and the reading on the instrument will be the same as if the couple had been originally joined.

The general arrangement of the parts forming the outfit for this class of temperature measurements is shown in the accom-

panying diagram as it would be applied for taking the temperature of a crucible of molten metal just before pouring.

The advantage of this plan is that the tips of the wires forming the elements almost instantaneously assume the temperature of the molten metal and time-lag error is eliminated.

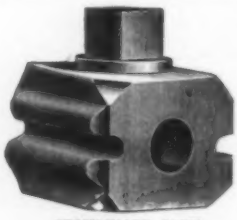
This form of couple has been most successfully applied to the measurement of molten metals, as cast iron, copper, aluminium, brass, bronze and other alloys.

When the tip of the couple becomes worn away by the continued use, a fresh portion is exposed to the molten metal and the reading will be the same as if the couple had not been reduced. A separable junction is provided, as shown in the diagram, so that fresh tips can be conveniently applied before enough of the couple has worn away to appreciably affect the resistance and cause an erroneous indication on the instrument. These instruments, which are being successfully used by a large number of manufacturers, are manufactured by William H. Bristol, 45 Vesey Street, New York City.

Stoneware Cocks.

As a substitute for threaded and flanged stoneware cocks in metal pipe lines, etc., the Charles Graham Chemical Pottery Works have designed and put on the market a cock in block form which has certain evident advantages, particularly those of strength and durability.

The cock consists of a block of stoneware, square in pattern, with longitudinal grooves on either side, as shown in the illustration. The faces at either end are ground true and parallel so that connection may be made directly to metal or other flange union, thus avoiding the necessity of lead burning.



STONEWARE COCK.

The grooves at the side are designed to accommodate bolts threaded at either or both ends, which are made fast in the flanges of the pipe sections.

These cocks are manufactured in sizes from ¾ inch to 3 inches. The larger sizes are made with two grooves on either side to accommodate four bolts. While the price of these cocks is slightly higher than for the ordinary plain or threaded straightway cocks, they have the inherent advantage of being stronger than any other design of stoneware faucet, being practically a solid block of stoneware without any weak points. Where pipe lines and apparatus in chemical works are subject to more or less severe strain these cocks should be found most useful.

Notes.

Dry-Blast.—The Warwick furnace No. 2, at Pottstown, Pa., is being equipped for running with dried blast by the Gayley system. The refrigerating apparatus is now being installed at a cost of nearly $250,000, and will be ready for operation in August. Meanwhile, Mr. Edgar S. Cook and his able assistants are keeping very complete records of the running of the furnace in order that the effect of using the dried blast may be accurately estimated. As soon as complete figures will be available we will place them before our readers.

The American Electric Furnace Co., with offices at 45 Broad Street, New York City, has been formed to take over all the business pertaining to electric furnaces heretofore carried on by the American Gröndal-Kjellin Co., of New York, under the patents of Mr. F. A. Kjellin, and by the Induction Furnace Company, of Newark, under the patents of Mr. E. A. Colby. The patents of these two chief workers in the field of the induction furnace have therefore now become the property of one company. The American Gröndal-Kjellin Co. will continue to carry on as heretofore all business relating to the concentration and crushing of ores, the manufacture of charcoal and the other special processes which have been developed by Mr. Gustaf Gröndal and his associates.

Nürnberg Gas Engines.—The Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nürnberg A. G., state in a recent circular that they have 250,000 hp. of their gas engines in operation, and furnish illustrated descriptions of some of their most recent installations, such as 3 machines of 1,950 hp. each, using blast furnace gas, at Differdingen; 4 of 900 hp, each, at Rombach in Lorraine; 4 of 2,700 hp. each, at Gelsenkirchen; 5 of 920 hp. each, using coke-oven gas, at Eschweiler, and 6 of 2,000 hp. each, using producer gas, at Madrid.

Fischer Gas Valve.—The Fischer & Demmler Co., at Mülheim-on-the-Ruhr, claim that 173 of their open-hearth reversing valves are in use, with an average economy of 20 per cent fuel over any other type of valve. The advantages claimed are that there is no possibility of gas leaks, no interruption of gas supply to the furnace, and no sucking-in of cold air into the furnace as with other types.

The Stuart & Peterson Co., of Burlington, N. J., have issued their new catalogue No. 116, covering appliances for chemists, druggists, bottlers, soap manufacturers, etc. This catalogue illustrates their full line of steam-jacketed kettles, both plain and porcelain lined, which they manufacture in capacities ranging from 10 gallons up to 500 gallons. A full line of mixing and stirring apparatus, vacuum pans, portable stills, retorts, percolators, emulsifiers and mixing machines are also illustrated; capacities of the various types of apparatus being given in full. This company also manufactures conveying kettles, caldrons, tanks and evaporating dishes with a high-grade porcelain lining which find considerable use among manufacturing chemists throughout this country. The manufacturers claim that the enamel used on their apparatus is the hardest known, and while it will resist most acids for years it is not guaranteed to stand extreme conditions indefinitely as an absolutely acid-proof enamel is unknown. Copies of the catalogue can be obtained from the Stuart & Peterson Co. on request.

Aluminium in Italy.—According to the *Electrical Review*, of London, May 24, an aluminium works has recently been erected near the town of Bussi, in the Abruzzi, by the Roman company which for some years past has owned a 4,000-hp. factory in the same neighborhood for the manufacture of caustic soda, bleaching powder, etc. A new power station has been built about 4 miles distant, and is developing power from the rivers Tirino and Pescara to the amount of 12,000 hp. From this station current is supplied to light and serve the towns of Aquila, Chieti and all the other places in the vicinity, and also to certain works where copper sulphate, artificial fertilizers and nitrogen compounds are being made. The aluminium factory is to obtain some of its bauxite from the mines at Lecce dei Marsi in the Province of Aquila, but the greater part will be procured from Japan.

Calcium Carbide in Ireland.—The *Electrical Review*, of London, remarks that there are a number of water powers in Ireland which might be used for the production of power for electrochemical processes. Several are being utilized for calcium carbide manufacture. Reference is made to an order recently placed by Mr. Frank Roadbent, consulting engineer, for a 640-hp. turbine coupled to a 430-kw-single-phase alternator. This forms the second set of this size for the works in question, and the turbine will operate on a 34-foot total fall and develop the power at 300 r. p. m. Owing to the possibility of getting the furnaces close up to the water power the alternators are run at low voltage, viz.: 50 volts, and are capable of developing up to 10,000 amps. They are self-regulating for constant output, and the turbines therefore are not hydraulically governed.

Glass Sand.—Approximately $65,000,000 worth of glass products were manufactured in the United States in 1905. The materials used cost about $18,000,000, and of this sum $1,000,000 was spent for sand. Sand forms from 52 to 65 per cent of the mass of the original mixture, or from 60 to 75 per cent of the finished glass products. The quality of the glass, its transparency, brilliancy and hardness, depend chiefly on the quality of the sand. Pennsylvania, Indiana and Ohio are the three chief States manufacturing glass products. In Bulletin 315, Contributions to Economic Geology, of the United Geological Survey, Mr. E. F. Burchard discusses the rock formations which in Ohio, Indiana and Kentucky furnish sand suitable for glass making and gives descriptions of the various properties now being developed.

Gas Power.—From a pamphlet of the Wile Power Gas Co., of Rochester, N. Y., manufacturers of complete gas power installations, gas producers and engines, we take the following figures of the fuel costs of 1-hp. year, generated from

	Per Hp-year.
Electricity, at 2 cents per horsepower-hour	$60.00
Gasoline, at 15 cents per gallon	45.00
Illuminating gas, at 75 cents per 1,000 cu. ft.	40.00
Cut-off steam engine, with coal at $4 per ton	24.00
Natural gas, at 30 cents per 1,000 cu. ft.	10.00
Producer gas from coal, at $4 per ton	6.00

In the above table, for steam power, a consumption of 4 pounds of coal per horsepower-hour has been assumed, which is exceedingly good non-condensing practice and only realized in large engines. Producer-gas power is cheap power, not only in fuel but also in attention required. The Wile Power Gas Co. manufacture gas producers to use non-bituminous coals, such as anthracite, semi-anthracite, coke and charcoal, as well as gas producers for bituminous fuels, such as soft coal, lignite, peat and wood, which operate with the same efficiency as the non-bituminous producers. These producers are tar-destroying and continuous cleaning.

Electrically-Singed Cotton Yarn.—At the recent cotton exposition in Philadelphia there was an interesting exhibit of an electric singeing method of cotton yarn which is an invention of Count von Moltke. The process is now being introduced in this country by the Société Electro-Textile, Messrs. Garner & Co., 10 Worth Street, New York City, being the agents. Connected with the usual processes of gassing yarns and cloths are several important disadvantages. Firstly, the cost of the gas consumed is very high, at least 95 per cent of the heat being wasted, which often renders a complicated and expensive system of ventilation necessary to reduce the temperature of the operating rooms and to withdraw the obnoxious gases of combustion. Secondly, variations in the pressure of the gas at different hours of the day cause a corresponding irregularity in the degree of gassing, which may be still further increased by the slightest current of air in the vicinity of the burners. Finally, materials under treatment are often discolored by impurities in the gas and acquire more or less of an odor. The electric singeing with its marked superior thermal efficiency disengages very little waste heat, the yarns are less discolored and their odor is less noticeable. Furthermore, the process permits of a perfect regulation of temperature to suit the various sizes and running speeds of the materials. As the "voltage per burner" does not exceed 3 volts there can be no danger to operators.

Belgian Zinc Industry.—A recent consular report of Mr. J. C. McNally deals with the zinc industry in Liege and in Belgium in general. In 1906 the zinc market was particularly active and the demands exceeded the supply. The yearly average price was $129.94 per metric ton (2,205 pounds), or $8.12 higher than in the previous year. In 1906 the Liege Company produced 93,040 tons of ingots, 67,253 tons of rolled sheets, and 9,442 tons of oxide. Of the latter the United States received $43,690 worth. The ore production of the company in various parts of the world for 1906 was 123,954 tons of zinc and 5,832 tons of lead ore. They also imported 158,624 tons of ores purchased abroad. The total importation of zinc ores into Belgium during 1906 amounted to 523,096 tons, of which Sardinia furnished 109,046 and Australia 122,279. The production of spelter in Belgium was 150,060 tons in 1906 against 143,300 tons in 1905. The total production of spelter in the United States, Europe and Australia is given as 690,965 tons against 647,720 in 1905. Following is a table of the production and the quantities contributed by the different countries:

	1906. *Tons.*	1905. *Tons.*
United States	198,910	180,360
Belgium	150,060	143,300
Rhine district, Germany	67,615	66,185
Holland	14,420	13,550
Great Britain	51,760	50,125
France and Spain	52,940	49,575
Silesia, Germany	134,180	127,895
Austria and Italy	10,610	9,210
Poland, Germany	9,460	7,520
Australia	1,010	.....
Total	690,965	647,720

The average price of spelter ex ship London in 1906 was $136.29, against $122.79 in 1905. The average price of lead in 1906 was $83.97 per metric ton, against $66.48 in 1905.

Canadian Department of Mines.—At the last session of the Canadian Parliament a Department of Mines was created with a minister of the Crown in charge of it. The department consists of two branches: the Mines Branch and the Geological Survey Branch. The latter was formerly a separate department, but has now been abolished as such and made into a branch of the Department of Mines. The direction of the work of the Mines Branch dealing with all economical matters is in charge of the Director of Mines, Dr. Eugene Haanel, who has so highly distinguished himself during the last years in the electrometallurgy of iron and steel.

The **Stevens Institute of Technology** has appointed Miss E. M. Hawkins, graduate of the Pratt Institute Library School, to take charge of its library. An important feature of the library is that section devoted to patent literature, containing the patent gazettes and specifications. Prof. W. H. Bristol has contributed liberally to the support of this section.

Colorado School of Mines.—We have received Vol. I., No. 2 of the *Quarterly* of the Colorado School of Mines, Golden, Col. It contains on 150 pages full information on history, organization and equipment, the courses offered, etc. The number of students is at present 294.

The General Electric Company's San Francisco office is now permanently located in the Union Trust Building in San Francisco. Since the fire the office has been located in the Union Savings Bank Building at Oakland, large temporary warehouses having also been erected in the same city.

Electric Smelting of Iron Ore in California.—The plant of the Noble Electric Steel Co., at Héroult-on-the-Pitt, is now in course of erection. Dr. Héroult has arrived at the spot where his engineers, Messrs. Turnbull, Petinot and Humbert, had preceded him to assist in the erection of the electric furnace plant.

Electrodeposition of Iron.—In the London *Electrical Engineering* of June 13 we notice mention of a recent patent of Sherard Cowper-Coles for the electrodeposition of iron, suitable for the production of tubes, sheets or wire, with a bright smooth surface, from a solution which is maintained charged with iron oxide. The solution contains 20 per cent of sulphocresylic acid saturated with iron, and the current density is 100 amps. per square foot of cathode surface. The voltage

is 3.25, the distance apart of anode and cathode ½ inch, and the temperature of the electrolyte is maintained at exactly 70° C.

Electric Tube Furnace.—The Féry-Langlet tube furnace, which was exhibited at the recent exposition of the French Physical Society in Paris, and is described in *La Revue Electrique*, May 30. The tube consists of magnesia, which is impermeable for gases and is not reduced by carbon at temperatures up to 2,000° C. This magnesia tube is surrounded by a graphite tube into which is cut a helical slot so as to form a helical graphite resistor. The electric current in passing through this graphite helix generates the heat. The graphite resistor is protected against oxidation by packing around it a dense layer of powdered carbon, which is a poor conductor of electricity and heat, the whole being included in a metallic envelope. When the furnace is heated for the first time the powdered carbon combines with the oxygen of the air within the envelope so that an inert atmosphere of oxide of carbon and nitrogen is produced.

French Electrochemical Society.—In a recent issue of the *Revue d'Electrochemie et d'Electrometallurgie* the suggestion is made to form a French Electrochemical Society. While the United States, Germany and England have their electrochemical societies none has been formed in the past in the country of Berthelot, Moissan and Héroult, where so much has been accomplished in recent years in industrial electrometallurgy.

Bunsen Society.—The annual convention of the Bunsen Society was recently held in Hamburg. One of the features was a symposium of papers on radioactivity. A full report will be given later.

American Electrochemical Society.—At the meeting of the board of directors, held in Philadelphia on June 1, the following gentlemen were elected members of the society: Allerton S. Cushman, chemist of the Department of Agriculture, Washington, D. C.; Royd R. Sayers, instructor in electrochemistry, Indiana University, Bloomington, Ind.; John F. Hammond, electrical designer, S. S. White Dental Manufacturing Co., Princes Bay, S. I., N. Y.; J. B. DuFaur, assayer, Mt. Morgan Gold Mining Co., Turramurra, Sydney, Australia; John L. Tufts, chemical engineer, Merrimac Chemical Co., Winchester, Mass.; William M. Grosvenor, consulting engineer, 1202 Townsend Building, Twenty-fifth and Broadway, New York City; J. Forsell, chemist, National Carbon Co., Cleveland, Ohio; Joseph B. Crane, assistant foreman, testing department, General Electric Co., Schenectady, N. Y.; George A. Richard, director, Electrolytic Refining Co., Mt. Morgan, Queensland, Australia; John F. Queeny, president, Monsanto Chemical Works, St. Louis, Mo.; Frank W. Liepsner, assistant in chemistry, University of Missouri, Columbia, Mo.; Charles F. Lindsay, research chemist, General Electric Co., Schenectady, N. Y.; Roger C. Wells, instructor in physical chemistry, University of Pennsylvania, Philadelphia, Pa.; A. Henry Pikler, electrical engineer, Crocker-Wheeler Electric Co., Montclair, N. J.; Stanislaus Skowenski, chemist, American Smelting & Refining Co., 54 High Street, Perth Amboy, N. J. At the meeting of the board of directors, held in New York City on June 29, the following gentlemen were elected members of the Society: Walter E. F. Bradley, electrochemist, New York City; Leland M. Willey, chemist, General Electric Co., Schenectady, N. Y.; Walter Renton Ingalls, editor, *Engineering and Mining Journal*, New York City; Herbert R. Moody, associate professor of chemistry, Stevens Institute, Hoboken, N. J.; Alcan Hirsch, student of chemistry, University of Texas, Austin, Tex.; Fritz Zimmerman, chemist with Baker & Co., Newark, N. J.; Harry McCormack, associate professor of industrial chemistry, Armour Institute, Chicago, Ill.; Morris Medove, student electrical engineer, Newark, N. J.; J. Harry Casselberry, electrician, Pennsylvania Railroad, Altoona, Pa.; Heinrich Wohlwill, electrochemist, Norddeutsche Affinerie, Hamburg, Germany. The next meeting of the Society will be held in Autumn, in New York City. While the exact date has not yet been decided upon, it will probably be held early in October. One of the features of the meeting will be a symposium of papers on the electrometallurgy of iron and steel.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

Calcium Carbid (*Continued*).

No. 562,402, June 23, 1896, W. R. King and F. Wyatt, of New York, N. Y.

Produces a nugget or ingot of calcium carbid in a pile of pulverized coke and lime, preferably equal parts, by placing a vertical resistance rod of carbon or coke in the pile, with its ends in contact with terminal electrode rods of larger cross-section. The upper terminal is carried by slides and rests directly upon the core, thereby maintaining contact as the core and charge fuse and shrink. The charge-material may be heaped around the core, or may be first piled up and the core pushed down into it. The pile may be shored up by planks or bricks. A direct or alternating current is passed through the core until lowered voltage or increased resistance shows that the current is no longer fusing the charge. The gases pass to the surface of the heap and burn. If they escape too freely at any point the workmen shovel charge-material onto the flame. Notwithstanding the high temperature required to produce calcium carbid, specified as about 5,000° F., the surface of the mound, except where the gases are burning, does not feel uncomfortably warm to the hand. At the end of the operation the white-hot ingot, which replaces the core, is lifted out, for example, by tongs carried on a swinging frame, a new core is put in place and the material piled around it for another operation. The process is said to be applicable to the production of carbids of other alkali and alkaline-earth metals.

No. 563,527, July 7, 1896, Thomas L. Willson, of New York, N. Y.

Subjects a mixture of finely-divided anhydrous calcium oxid, 65 per cent, and carbon, preferably coke, 35 per cent, to the action of an electric arc in a furnace. Hydrocarbons may be added to the charge, or the lime may be saturated with a liquid hydrocarbon. The furnace is preferably a graphite crucible connected to one terminal and receiving a carbon pencil connected to the other terminal. In starting the carbon pencil is brought into contact with the crucible, then lifted to srike an arc, and lifted during the operation to maintain the arc by maintaining a space between the pencil and the conductor beneath. Disclaims the making of metallic alloys by alloying the metal of the electrode with the metal of a bath.

No. 563,528, July 7, 1896, Thomas L. Willson, of Brooklyn, N. Y.

Produces calcium carbid by smelting a mixture of powdered quicklime and coal in *e. g.*, a Siemens arc furnace. Or the lime may be slacked and stirred into liquid coal tar, dried and smelted. Or the lime and carbonaceous matter may be charged into the furnace during the smelting operation. Or the heavy carbon pencils or slabs of the furnace may serve as the scource of carbon, though this is uneconomical. The carbid may be tapped out of the furnace at a white heat, or may be removed at the end of the operation. It is friable and iron-gray or bluish-gray. If exposed to the air it gradually crumbles to powder, its surface turning to a whitish-gray by oxidation to lime. It may be preserved in moisture-excluding vessels or beneath oil. The second step of the invention is the production of acetylene from the carbid by dropping it into water, 1 pound of carbid giving about 5.5 cubic feet of acetylene. The Third step of the invention is the production of an illuminant by mixing the acetylene with atmospheric air. The acetylene may be used to enrich water-gas, producer-gas or other illuminating gas.

NEW BOOKS.

COMMERCIAL ORGANIC ANALYSIS. A treatise on the properties, modes of assaying and proximate analytical examination of the various organic chemicals and products employed in the arts, manufactures, medicines, etc., with concise methods for the detection and determination of their impurities, adulterations and products of decomposition. By Alfred H. Allen. Third edition; rewritten and revised. Vol. II., Part III. Acid derivatives of phenols, aromatic acids, resins and essential oils. Revised by the author and Arnold Rowsby Tankard. 547 pages; 2 illustrations and numerous tables. Bound in cloth. Price, $5.00 net. Philadelphia: P. Blakiston's Son & Co.

OUTLINES OF INDUSTRIAL CHEMISTRY. A text-book for students. By Frank Hall Thorp. Second revised and enlarged edition, with a special chapter on metallurgy by C. D. Demond. 733 pages; illustrated. Bound in cloth. Price, $3.75 net. New York: Macmillan Co.

METALLURGICAL CALCULATIONS. By Joseph W. Richards, A. C., Ph. D., professor of metallurgy in Lehigh University. Part II.: Iron and Steel. 444 pages. Price, $2.00. New York: McGraw Publishing Co.

LIBRARY OF CONGRESS: SELECT LIST OF BOOKS WITH REFERENCE TO PERIODICALS RELATING TO IRON AND STEEL IN COMMERCE. Compiled by A. P. C. Griffin. 25 pages. Paper binding. Price, 15 cents. Washington, D. C.: Office of the Superintendent of Documents.

FURTHER RESEARCHES CONCERNING ATOMIC WEIGHTS OF POTASSIUM, SILVER, CHLORINE, BROMINE, NITROGEN AND SULPHUR. By Theodore W. Richards, Arthur Staehler and others. Paper binding. 88 pages with diagrams and illustrations. Price, 50 cents. Washington, D. C.: Carnegie Institution of Washington.

THE COMPRESSIBILITY OF THE ELEMENTS AND THEIR PERIODIC RELATIONS. By Theodore W. Richards, W. W. Stull, F. N. Burk and F. Bonnet, Jr. 67 pages; illustrated; paper cover. Price, 50 cents. Washington, D. C.: Carnegie Institution of Washington.

MATHEMATICS FOR ENGINEERING STUDENTS; ALGEBRA AND TRIGONOMETRY. By S. S. Keller. 254 pages; illustrated. Price, $1.50 net. New York: D. Van Nostrand Co.

MINE TIMBERING. By Wilbur E. Sanders, Bernard McDonald and Norman W. Parlee. 180 pages; illustrated. Bound in cloth. Price, $2.00 net. New York: Hill Publishing Co.

MINES AND MINERALS. Examination questions for certificates of competency as mine inspector, mine foreman, mine manager, fire boss, hoisting engineer, etc., as given by the State Examining Boards, together with answers. 600 pages; illustrated. Price, $3.50 net. Scranton, Pa.: Mines and Minerals.

PRELIMINARY ACCOUNT OF GOLDFIELD, BULLFROG AND OTHER MINING DISTRICTS IN SOUTHERN NEVADA. 104 pages; illustrated by maps and drawings. Paper binding. 15 cents. Washington, D. C.: Superintendent of Documents.

GOLD SUPPLY AND PROSPERITY. By Byron W. Holt. 180 pages; illustrated. Bound in cloth. Price, $1.00 net. New York: Moody Corporation.

LABORATORIUMSBÜCHER FÜR DIE CHEMISCHE UND VERWANDTE INDUSTRIEN. Edited by Max Wohlgemuth, literarisch-wissenschaftlichem Beirat in der Chemischen Fabrik Th. Goldschmidt, Essen-Ruhr. Vol. I. Laboratoriumsbuch für den Eisenhüttenchemiker. By Max Orthey. 49 pages. Price, mark 1.80 (retail price in New York, 60 cents). Halle a. S.: Wilhelm Knapp.

GERMAN MONOGRAPHS ON METHODS OF MANUFACTURE IN CHEMICAL TECHNOLOGY. Edited by L. Max Wohlgemuth. Halle a. S.: Wilhelm Knapp:

Vol. I. "Der Fabrikchemiker, seine Ausbildung und Stellung." By L. Max Wohlgemuth. Price, mark 1.

Vol. II. "Die Industrie des Braunkohlenteers." By Dr. Ed. Graefe. Price, mark 3.60.

Vol. III. "Die deutsche Kaliindustrie." By Dr. Konrad Kubierschky. Price, mark 3.80.

Vol. IV. "Das Porzellan." By Dr. R. Dietz. Price, mark 3.20.

Vol. V. "Die Superphosphatfabrikation." By Dr. Ritter von Grueber. Price, marks 3.

Vol. VI. "Die Fabrikation von Sulfat und Salzsäure." By Dr. Theodor Meyer. Price, marks 3.40.

* * *

At the suggestion of some correspondents we herewith give a complete list of all volumes which have so far been published in the serial of GERMAN MONOGRAPHS ON APPLIED ELECTROCHEMISTRY, edited by Victor Engelhardt and published by Wilhelm Knapp, Halle a. S. We also state whether a translation into English has been published.

Vol. I. "Electrolysis of Water, Its Operation and Applications." By Victor Engelhardt. Price (in German) marks 5. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. II. "The Manufacture of Aluminium and Its Uses in Commerce and Industry." By A. Minet and E. Abel. Price, marks 7. English translation by L. Waldo. $2.50. New York: John Wiley & Sons.

Vol. III. "The Manufacture of Chromium and Its Compounds with the Aid of the Electric Current." By Prof. Max LeBlanc. Price (in German), marks 6. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. IV. "The Arrangement of Electric Laboratories with Special Reference to the Requirements of Metallurgical Practice." By H. Nissenson. Price (in German), marks 2.40. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. V. "The Production of Metallic Objects Electrolytically and Electroengraving." By Dr. W. Pfanhauser. Price (in German), marks 7. English translation by J. W. Richards. $1.25. Easton, Pa.: Chemical Publishing Co.

Vol. VI. "Electrometallurgy of Nickel." By Prof. W. Borchers. Price, marks 1.50 (only in German).

Vol. VII. "Cyanide Processes for Winning Gold." By M. von Uslar and Dr. G. Erlwein. Price, marks 4 (only in German).

Vol. VIII. "Hypochlorites and Electric Bleaching. Operation in Practice." By Victor Engelhardt. Price, marks 12 (only in German).

Vol. IX. "Electrometallurgy of Alkali Metals." By H. Becker. Price, marks 6 (only in German).

Vol. X. "Electrolytic Refining of Copper." By Titus Ulke. Translated into German by Victor Engelhardt. Price, marks 8. The original American edition is published under the title "Modern Electrolytic Copper Refining," by Titus Ulke. Price, $3.00. New York: John Wiley & Sons.

Vol. XI. "Galvanoplastik." By W. Pfanhauser. Price, marks 4 (only in German).

Vol. XII. "The Electrochemical Industry of Germany." By Dr. P. Ferchland. Price, marks 2.50 (only in German).

Vol. XIII. "Carborundum." By F. A. J. FitzGerald. Translated by Dr. Max Huth. Price, marks 2 (only in German).

Vol. XIV. "Electrolytic Preparation of Parabolic Mirrors." By Sherard Cowper-Coles. Translated by Dr. Emil Abel. Price, mark 1 (only in German).

Vol. XV. "Artificial Graphite." By F. A. J. FitzGerald. Translated by Dr. Max Huth. Price, marks 3 (only in German).

Vol. XVI. "Electrolytic Production of Zinc." By Dr. Emil Günther. Price, marks 10 (only in German).

Vol. XVII. "Hypochlorites and Electric Bleaching. Theory." By Dr. Emil Abel. Price, marks 4.50 (only in German).

Vol. XVIII. "Electroplating with Zinc." By Sherard Cowper-Coles. Translated by Dr. Emil Abel. Price, marks 2 (only in German).

STANDARD BOOKS

METALLURGY

ORE DRESSING
By ROBERT H. RICHARDS
Of the Massachusetts Institute of Technology
Two volumes, 6½ x 9½, cloth, 1250 pages, profusely illustrated, per set $10.00.

MODERN COPPER SMELTING
By EDWARD DYER PETERS
600 pages 6½ x 9½, cloth, $5.00.

PRINCIPLES OF COPPER SMELTING
By EDWARD DYER PETERS
Professor of Metallurgy, Harvard University
612 pages 6½ x 9½, cloth, $5.00.

PYRITE SMELTING
By T. A. RICKARD
210 pages 6½ x 9½, $2.00.

THE METALLURGY OF LEAD
By H. O. HOFMAN
Professor of Metallurgy, Massachusetts Institute of Technology
600 pages 6½ x 9½, $6.00.

HYDROMETALLURGY OF SILVER
By OTTOKAR HOFMANN
336 pages 6½ x 9½, cloth, $4.00.

MANUFACTURE AND PROPERTIES OF IRON AND STEEL
HARRY HUSE CAMPBELL
640 pages, 6 x 9, illustrated, $5.00.

METALLURGICAL CALCULATIONS
PART I. CHEMICAL PRINCIPLES
By PROF. JOSEPH W. RICHARDS
200 pages, cloth, $2.00 net.

METALLURGICAL CALCULATIONS
PART II. IRON AND STEEL
By PROF. JOSEPH W. RICHARDS
250 pages, cloth, $2.00 net.

IRON, STEEL AND OTHER ALLOYS
By PROF. HENRY M. HOWE
Second edition, 513 pages, 123 illustrations. Price $5.00 net.

METALLURGICAL LABORATORY NOTES
By PROF. HENRY M. HOWE
154 pages, 44 illustrations. Price, $2.50 net.

In this book the author describes ninety-one laboratory experiments conducted by students in the Department of Metallurgy of the School of Mines of Columbia University, and deals with Pyrometry, Calorimetry, Metallography, Heat Treatment of Steel, etc.

ELECTROMETALLURGY

ELECTRIC SMELTING AND REFINING
By DR. W. BORCHERS. Translated by W. G. McMILLAN.
Second edition, 562 pages, 255 illustrations. Price, $7.00.

This book treats of all those metals in the extraction and working of which the electric current has found any application. A survey of the purely metallurgical methods of treatment has been added to each chapter, so the two methods may be readily compared.

THE ELECTRIC FURNACE
By HENRI MOISSAN
Authorized Translation By DR. VICTOR LENHER
305 pages, illustrated. Price, $2.50.

A complete description of this recent apparatus and its application to the fusion and volatilization of refractory substances. The work is brought up to date by accounts of recent development.

Any of the above books sent postpaid on receipt of price.

We can promptly furnish any Metallurgical, Chemical or Engineering book.

ELECTROCHEMICAL PUB. CO.

Book Dept. **114 Liberty St, New York**

Vol. XIX. "The Electrolytic Chlorate Industry." By J. B. C. Kershaw. Translated by Dr. Max Huth. Price, marks 6 (only in German).

Vol. XX. "Electrolysis of Fused Salts." Part I., Compounds and Elements. By Prof. R. Lorenz. Price, marks 8 (only in German).

Vol. XXI. "Electrolysis of Fused Salts." Part II., Faraday's Law, Transport and Migration of Ions, Conductivity. By Prof. R. Lorenz. Price, marks 8 (only in German).

Vol. XXII. "Electrolysis of Fused Salts." Part III., Electromotive Force. By Prof. R. Lorenz. Price, marks 10 (only in German).

Vol. XXIII. "Electrolysis of Alkali Chlorides with Fused Metallic Cathodes." By Dr. R. Lucion. Price, marks 9 (only in German).

Vol. XXIV. "German Patents Relating to Electrochemistry." By Dr. P. Ferchland and Dr. P. Rehländer. Price, marks 10 (only in German).

Vol. XXV. "German Patent Law for Chemists." By Dr. P. Ephraim. Price, marks 18 (only in German).

Vol. XXVI. "Electrometallurgy of Iron and Steel." By Prof. B. Neumann. Price, marks 7 (only in German).

Vol. XXVII. "Electrolytic Production of Bromine and Iodine." By Dr. Max Schlötter. Price, marks 2.40 (only in German).

BOOK REVIEWS.

Metallurgical Calculations. Part II., Iron and Steel. By Joseph W. Richards, A. C., Ph. D. 444 pages. Price, $2.00 net. New York: McGraw Publishing Co.

This is a reprint in book form of the series of articles which appeared in Electrochemical and Metallurgical Industry from April, 1906, to May, 1907. "The intention is to show how the general chemical, physical and mechanical principles which were elucidated at length in Part I., can be applied to solving the special problems arising in the metallurgy of iron and steel. To this end descriptions of processes have been made as brief as was consistent with the clear statement of the particular principles involved, and familiarity with the general principles explained in Part I. has been assumed. To gain advantage from the use of this work, the student or reader should master the principles taught in Part I., and possess a certain body of information as to the modus operandi of the various processes of making iron and steel."

The twelve chapters of the book deal, respectively, with the material balance sheet of the blast furnace; calculation of a furnace charge; utilization of fuel in the blast furnace; the heat balance sheet of the blast furnace; rationale of hot blast and dry blast; production, heating and drying of blast; the Bessemer process; thermochemistry of the Bessemer process; the temperature increment in the Bessemer converter; the open-hearth furnace; thermal efficiency of open-hearth furnaces; the electrometallurgy of iron and steel. The principles are fully illustrated in eighty problems, the solutions of which are given in full.

An appendix contains twenty additional problems for practice, without solution, although the final answer is given.

* * *

Table of Volumes Through Air-Ways. By C. H. Kuderer. Pasted on cardboard. Price, 25 cents. Allegheny, Pa.: E. E. Meyer.

This is a table of volumes through air-ways in cubic feet per minute, calculated on the basis of Atkinson's formula, by Mr. H. C. Kuderer, general manager of the Avonmore Mine Fan Co. The table is very handy and should prove useful as reference for engineers who meet with problems of air transmission through large air-ways.

A TEXT BOOK OF ELECTROCHEMISTRY. By Max Le Blanc, professor in the University of Leipzig. Translated from the fourth enlarged German edition by Willis R. Whitney, Ph. D., director of the research laboratory of the General Electric Co., and John W. Brown, Ph. D., director of the research and battery laboratory of the National Carbon Co. 338 pages; illustrated. Price, $2.60 net. New York: The Macmillan Co.

We have recently commented on the fourth German edition of this excellent textbook. Almost simultaneously with it the American edition has appeared. Compared with the first American edition, which was a translation of the first German edition, the new edition is almost a new book. The translators have paid special attention to notation and nomenclature, and their endeavors in this direction deserve more than passing notice.

While the nomenclature has been made to conform to that of the best recent textbooks of electricity and chemistry, a complete, consistent system of notation has been devised which is used uniformly throughout the book. We believe that this has never been done before with equal consequence. There may be details in which others will disagree with Dr. Whitney and Dr. Brown. For instance, they use the symbol *c* for electric current; this is decidedly English usage, while in this country, France and Germany, electrical engineers prefer the symbol *i*. The translators write Q underscored for the electrochemical unit of quantity of electricity, *i. e.*, 96,540 coulombs, while the symbol F (Faraday) is now being widely used for the same quantity. In the Whitney-Brown system F stands for force, both for mechanical force and for electromotive force—which are two very different things, so that they have to be distinguished by indices. But all such objections are small matters. The fact remains that the notation used by the translators is consistent in itself.

Prof. Le Blanc now occupies Ostwald's old chair in Leipzig, while Dr. Whitney and Dr. Brown are prominently connected with industrial progress in this country. It is therefore but natural that their textbook is not only a reliable and representative statement of modern theory, but that it is a statement in such form as to make the theory applicable to the needs of the research chemist for industrial ends.

* * *

POPULÄRE SCHRIFTEN. By Ludwig Boltzmann. 440 pages. Price in paper cover, marks 8; bound, marks 9 (retail price in New York, $2.65 and $3.00, respectively). Leipzig: Johann Ambrosius Barth.

Ludwig Boltzmann was one of the most brilliant and successful leaders and workers in theoretical physics. His influence was very widely felt; his strong personality impressed itself on many of the advances which have been made in thermodynamics and gas theory, in the development of Maxwell's electromagnetic theory, in the principles of mechanics, etc. In the preface to one of his volumes on Maxwell's theory he quotes the sentence: "Wenn die Könige baun, haben die Kärrner zu thun." He refers to Maxwell as a König and to himself, with utmost modesty, as a Kärrner. But we know that he was far more. If he had done nothing else—and he has done so much more—the Boltzmann-Stefan radiation law would make his name immortal.

Boltzmann was not only a clear-headed and immensely resourceful physicist and brilliant mathematician, he was a man of strongest personality. Many of his most characteristic human traits are exhibited in the present book, which is a collection of his "popular writings" and which appeared not long before his lamentable death by his own hand last Autumn.

The title, Popular Writings, is very indefinite and may even be misleading. The twenty-three articles, papers, lectures and reviews collected in the book are of a very heterogeneous character. Article No. 1 deals with "the methods of theoretical physics," explaining the usefulness of dynamical illustrations and mechanical analogies. Article 2 gives a concise

JUST READY

"FOODS AND THEIR ADULTERATIONS"

The Origin, Manufacture and Composition of Food Products, Description of Common Adulterations, Food Standards, and National Food Laws and Regulations

By HARVEY W. WILEY, M. D.

Chief Chemist, U. S. Department of Agriculture, Washington, D. C.

A guide to the chemist in detecting impurities in food.

11 Colored Plates and 86 other Illustrations

Octavo: 625 pages Cloth, $4.00 net

Synopsis of Contents:—Introduction.—Meats.—Poultry and Game Birds.—Fish Foods.—Milk and Milk Products.—Cereal Foods.—Invalid and Infant Foods.—Vegetables, Fruits, Spices, Nuts, Etc.—Sugar and Honey.—Food Standards, Rules and Regulations for Enforcing the Food and Drugs Act.—Regulations Governing Meat Inspection.—Index.

Orders may be sent to any bookseller; or upon receipt of price we will forward to any address, postage or express charges prepaid.

P. Blakiston's Son & Co.

SCIENTIFIC PUBLISHERS

1012 Walnut St., Philadelphia

Handbook of Mathematics

FOR ENGINEERS AND ENGINEERING STUDENTS

By J. CLAUDEL

Translated and Edited from the Seventh French Edition by OTIS ALLEN KENYON

A complete book on Mathematics
It covers very thoroughly
Every branch from Arithmetic to Calculus

TABLE OF CONTENTS

PART I.—ARITHMETIC. I.—Fundamental Operations on Whole Numbers. II.—Properties of Whole Divisors. III.—Fractions and Decimal Numbers. IV.—Powers and Roots. V.—Ratios, Proportions, Progressions. VI.—Diverse Rules. VII.—Logarithms. PART II.—ALGEBRA. I.—Of the Four Fundamental Algebraic Operations. II.—Equations of the First Degree. III.—Powers and Roots of the Algebraic Quantities. IV.—Equations of the Second Degree. PART III.—GEOMETRY. Plane Geometry. Solid Geometry. Problems in Geometry. PART IV.—TRIGONOMETRY.—Plane. Spherical Trigonometry. PART V.—ANALYTICAL GEOMETRY. PART VI—CALCULUS. I.—Differential Calculus. II.—Integral Calculus. III.—Applications of Integral Calculus.

Cloth, 708 Pages. 422 Illustrations. Price, $3.50 Net.

Sent anywhere postpaid for the price

Send Us Your Inquiries Write For Our Catalogs

McGraw Publishing Company

PUBLISHERS, IMPORTERS AND BOOKSELLERS

114 Liberty Street, New York

DUHEM-BURGESS—*Thermodynamics and Chemistry.* A Non-Mathematical Treatise for Chemists and Students of Chemistry. By P. Duhem, Correspondant de l'Institut de France; Professor of Theoretical Physics at the University of Bordeaux. Authorized Translation by George K. Burgess, Docteur de l'Université de Paris; 8vo, xxi + 445 pages, 140 figures. Cloth, $4.00.

GETMAN—*Laboratory Exercises in Physical Chemistry.* By Frederick H. Getman, Ph. D., Fellow by Courtesy of The Johns Hopkins University, Carnegie Research Assistant. 12mo, viii + 241 pages, 100 figures. Cloth, $2.00 net.

LÖB-LORENZ—*Electrochemistry of Organic Compounds.* By Dr. Walther Löb, Privatdocent in the University of Bonn. Authorized Translation by H. W. F. Lorenz, A.M., Ph.D., 8vo, x + 308 pages, 10 figures. Cloth, $3.00.

WEAVER—*Notes on Military Explosives.* By Erasmus M. Weaver, Lt. Col. Artillery Corps, U. S. Army. 8vo, viii + 311 pages. Cloth, $3.00 net.

JOHN WILEY & SONS
43 & 45 E. 19th St., New York City

Eleventh Edition

Metallurgy of Cast Iron

A complete exposition of the processes involved in its treatment, chemically and physically, from the blast furnace through the foundry to the testing machine, being a practical compilation of original research.

By THOMAS D. WEST

Contents

PART I.—Manufacture and Use of Coke—Properties in Ores—Operations of Blast Frunaces—The Different Brands of Pig-Iron and How to Purchase and Use Them Intelligently (27 chapters). II.—Elements in Cast-Iron and Their Physical Effect—Utility of Chemical Analyses and How to Use Them in Making the Different Mixtures of Irons Used in Making Gray and Chilled Castings (21 chapters). III.—Properties of and Methods for Testing Molten Iron—Phenomena in the Actions of Cooling Metal, etc.—Results of Tests in All Kinds of Irons—Best Methods for Testing (23 chapters). APPENDIX. Selected Tables for Use in Furnace and Foundry Work.

Cloth 638 Pages 153 Illustrations Price, $3.00 net

Sent Anywhere, postpaid, for the Price by the

McGRAW PUBLISHING COMPANY

114 Liberty Street :: New York

and elementary statement of the fundamental conceptions of Maxwell's theory of electromagnetism. No. 3 deals with the second principle of thermodynamics, entropy being defined as the degree of probability of the distribution of different forms of energy. No. 4 is the famous address presented by Boltzmann as rector of the University of Graz in memory of Gustav Robert Kirchhoff. If anybody has ever been able to explain in words why mathematics is an art and how a mathematical paper may be beautiful, Boltzmann has succeeded in doing so in this address by means of analogies between the working methods of the musician and of the mathematical physicist. No. 5 is a brief discourse on the importance of theories or of pure theory, No. 6 deals with problems of aeronautics, No. 7 is the address held at the unveiling of the monument in memory of Josef Stefan.

Nos. 8 and 9 are papers dissecting critically and caustically the methods of modern "energetics," *i. e.*, the new thermodynamical school of Ostwald and others. Boltzmann shows first that in the field of mechanics the methods of energetics have been almost absolutely barren of results. He then analyzes the methods of energetics in thermodynamics, and finally goes on record with respect to some points brought out in Ostwald's well-known lecture on scientific materialism. Boltzmann emphasizes that he considers those men against whom he speaks here to be his personal friends, and that he considers their work in other fields but energetics as of greatest importance. But he sees a great danger in the advance of energetics. "Quite often young men now enter the field of energetics which promises easy results, while they have not the necessary mathematical training and judgment required for successful work in theoretical physics." Every chemist who might be tempted to become an amateur in energetics should read this chapter of Boltzmann. In Nos. 10 and 11 Boltzmann endeavors to show why physics cannot get along without the atomic theory. No. 12 is a critical discussion of the question of the objective reality of the phenomena in lifeless nature.

No. 13 is a brief elementary discussion of Roentgen rays. No. 14 is a lecture giving an historical review of the development of the methods of theoretical physics in recent times and of the different schools. No. 15 is an account of the life and work of Josef Loschmidt. No. 16 gives the four lectures held by Boltzmann in 1899 at Clark University, on the fundamental principles and fundamental equations of mechanics, No. 17 two further general lectures on the principles of mechanics, while No. 18 is the first of a series of lectures held by Boltzmann on "Naturphilosophie." No. 19 is Boltzmann's lecture held at the Scientific Congress in St. Louis on statistical mechanics. No. 20 shows Boltzmann again in a controversy with Ostwald, with respect to the latter's theory of happiness; in the first part Boltzmann is scarcastic, and his aim is to make fun of the theory in question; later on he gets bitter in earnest.

No. 21 is a review of W. Vaubel's handbook of theoretical chemistry, No. 22 a critical discussion of Schopenhauer's philosophical system. The concluding article, No. 23, is the story of Boltzmann's trip to California, where he lectured at Berkeley. Of all articles in the book this one comes nearest the title popular writings. The story is written in a very amusing style, and in his sarcasms Boltmann does not even spare himself. He fully appreciates the beauties of California. "We may gather as much delight and happiness as there is room for in a human breast on a trip through the mountains of our fatherland. We may be as satisfied as a king at a simple meal. But a trip to California is champagne Veuve Clicquot and oysters." But this story also reveals Boltzmann's limitations, those of his stomach and those of the man. What he tells about the breakfast in Mrs. Hearst's house and especially about oatmeal, simply shows that even a man like Boltzmann may not resist the temptation to talk about things he does not understand. And it is a little doubtful if some parts of the story are in good taste. Taken as a whole, the book is, however, a delightful human document worthy of its author.